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U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB 286 689

ADG

TECH. INFO.

Evaluation of Metal Containers for Shipping Hazardous Materials

(U.S.) Naval Air Development Center, Warminster, PA

Prepared for

Department of Transportation, Washington, DC Office of Hazardous Materials

Sep 72

8000688

The contents of this report reflect the views of the Naval Air Development Center which is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policy of the Department of Transportation. This report does not constitute a standard, specification or regulation.

A B S T R A C T

An investigation was conducted to evaluate various types of new metal drums and pails being used for the packaging and shipping of hazardous materials, to determine if these containers will spill their contents when subjected to high internal pressure and to specified rough handling tests. Various quantities of 17H and 17C open head drums as well as samples of 37A and 37C drums and pails spilled liquid contents after rough handling. In addition, some 37A, 37B drums and 37A and 37C pails spilled their dry (powder) contents after rough handling.

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I N T R O D C T I O N

The Office of Hazardous Materials, Department of Transportation (DOT) initiated a project for the purpose of testing and evaluating the various types of new drums and pails being used for packaging hazardous materials. It is expected the data gathered will form a basis for potential, future regulatory amendment as well as to confirm generally the quality of drums and pails being furnished by and stated by the industry to conform with the requirements of Title 49 CFR Parts 170-189.

For this project, the Naval Air Development Center was supplied drums and pails submitted by members of the Steel Shipping Container Institute. In keeping with the DOT invitation to industry to witness the testing of the containers, various representatives witnessed these tests as listed in the Appendix.

S A M P L E S A N D P R E P A R A T I O N

The Naval Air Development Center received 289 containers, designed to conform to the DOT specifications, for testing. Of these, 165 were 55 gallon drums and 124 were 5 gallon pails which varied in the style of closure and gauge of the metal. Also included were the special mono-stress 55 gallon metal drums and some 55 gallon plastic drums. The number of containers received under each specification, the type of closures and gauge of metal used in each container are listed in Table 1. Containers designated for pressure tests were fitted with bulkhead nipples for pressurizing the containers. The nipple was placed in the center of

used for all open head 55 gallon drums as illustrated in Figure 1. The nipple was placed in the center of the bottom of all 5 gallon pails. On the closed head, 55 gallon drums, the 3/4 inch bung was adapted to pressurize the drums. No special preparations were required on those containers designated to be subjected to the drop tests.

PROCEDURE

Visual Examination. Each container was examined for dents, creases, type of seam and chimes, and repair if any. Gaskets were examined for material, conditions, type, mold marks and fit. Number of lugs and spacing on lug-head covers, number and distance between hoops were noted. The height of the drum, distance between the 2 inch and the 3/4 inch bung openings, diameter of containers and convexity in heads of drums were also noted. The markings were examined for size, whether they were embossed, and if they were complete with name, gauge, rated capacity, year of manufacture and DOT specification (see Table 2). Ten percent of the containers under each specification were measured for thickness (see Table 3). The gauge thickness of the containers was measured with an automatic ultrasonic Digital Thickness Gage, Model G2-B, illustrated in Figure 2. The measurements were made by placing a transducer, which had been calibrated, firmly in contact with the container, Figure 3. The ultrasonic signal emitted by the transducer passes through the material and is picked up and amplified by the unit. The thickness in thousandth of an inch was noted on the readout digital scale.

The gauges of the containers were found to be slightly thicker than

marked on the container. The general overall appearance and condition of the containers were good. A few minor dents and small areas where paint had been scuffed off in shipment were observed. Twelve 5 gallon closed head pails were received without flex spouts. Only three containers, one 55 gallon drum and two 5 gallon pails, all open head, were damaged in shipment to the extent they could not be tested. The open ends of these containers were bent out of round at the upper chime; therefore, the covers would not fit properly.

Hydrostatic Pressure Test. The containers were filled to 100 percent capacity with water, wiped dry, closed and sealed. The torque applied to the closed head containers depended on the type of gasket and type of fitting used. The torque in pound-feet for the 2 inch opening with the Rieke Corporation fitting was 40 with asbestos, 30 with Hycar (Buna), 40 with polyethylene, 30 with ethylene-propylene terpolymer, and 40 with Dapon. For the American Flange and Manufacturing Company 2 inch fitting, the torque in pound-feet was 15 with Buna rubber, 25 with polyethylene, and 40 with fiber. The 3/4 inch openings were not torqued because they were used to attach an air line for pressurizing the containers. The open head 55 gallon drums were torqued to 50 pound-feet. The 5 gallon pails fitted with a Rieke Flex Spout were closed and sealed using a Rieke Flex Spout Crimper. Five gallon open head pails were closed and sealed with a 16 lug pail crimper.

The equipment used to conduct this test consisted of (1) two high pressure and two low pressure gauges, (2) one pressure regulator, (3) one bleed-off and one cut-off valve, (4) four roll over drum stands, and (5)

Imperial Hand Model, 120 psig test capacity. All gauges were calibrated on 3 May 1972 using an Ashcroft Dead Weight Gauge Calibrator, Model 1390, Serial No. 11617/1742B.

The containers were placed on the roll over drum stand on their side with the locking ring joint, the 2 inch closure and the side seams down. Each container was pressurized to the test pressures listed below.

<u>Drum</u>	<u>Pressure (psig)</u>
DOT-5 (closed head)	40
DOT-5A	80
DOT-5B (closed head)	40
DOT-6J (closed head)	15 (10 gauge)
DOT-17C (closed head)	40
DOT-17C (open head)	20
DOT-17E	15
DOT-17H	15
DOT-37A (5 gallon)	7
DOT-37B (5 gallon)	7
DOT-37C	5
DOT-37D	15
Monostress II	40

The test pressures were maintained for 5 minutes or until leakage was noted, indicating a leak. The results reported in Table 4 reveal that eight drums and seven pails failed the test. The drum failures were noted as leaks at the locking ring joint for Exhibits 14, 38, 53, 57, 58, 92, 112, 113, and a leak at the 2 inch bung adaptor for Exhibit 125.

The pail failures were noted as a leak at the flex spout for Exhibit 29, a leak at the upper chime for Exhibit 36, and a leak at the cover for Exhibits 7, 48, and 73. The failures are illustrated in Figure 4 through Figure 11.

Pneumatic Leak Test. Containers subjected to this test were prepared, torqued, and tested using the same equipment as in the hydrostatic pressure test except empty containers were tested. The empty containers were pressurized to the internal air pressures listed below.

<u>Drum</u>	<u>Pressure (psig)</u>
DOT-5	15
DOT-5A	15
DOT-5B	15
* DOT-6C	15
* DOT-6J	15 (16 gage)
DOT-6J	7 (18 gage)
* DOT-6K	7
DOT-17C	15
DOT-17E (55 gallon)	7
DOT-17E (5 gallon)	5
* DOT-17F	15
DOT-17H (55 gallon)	7
DOT-37A (55 gallon)	7
DOT-37A (5 gallon)	5
DOT-37B (55 gallon)	7
DOT-37B (5 gallon)	5

* Not received

DOT-57C

5

DOT-57D

7

Monostress II

15

The pressures were maintained for 5 minutes or unless a leak was noted by a drop in the pressure gauge. After reaching the required pressure, a bubble supporting solution was applied to the seams, upper and lower chimes, and fittings. The containers were examined for evidence of leakage. The results reported in Table 4 reveal that no drums failed the test; however, five pails failed the test. The failures were noted as leaks at the lids for Exhibits 9, 10, 49, and 76. Exhibit 55 leaked at the intersection of the side seam and top chime. The type of failures are illustrated in Figures 12 and 13.

Diagonal Drop Test. Containers were filled with water to 98 percent capacity. The drums were filled to within 1-3/4 inches of the top and the pails within 1-1/2 inches of the top. Each container was closed and torqued as stated in the hydrostatic pressure test. The equipment consisted of a (1) crane for raising containers to drop height, (2) "Any Angle" drum lifter for positioning the drum for drop, (3) adjustable drum sling, and (4) a helicopter personnel automatic/manual quick release mechanism. A reinforced concrete pad 10 x 10 x 2 feet was used as the impact surface.

The containers were lifted using the drum lifter and positioned so that the head of the container faced downward and formed a diagonal with the impact surface as illustrated in Figure 14.

For the closed head containers, the 2 inch bung was placed in the center of the impact area. For the open head 55 gallon drum, the locking ring joint was positioned so it would impact the test pad. The containers were raised to the heights listed below and dropped diagonally on to the concrete pad.

<u>Specification</u>	<u>Height of Drop (feet)</u>
DOT-5	4
DOT-5A	6
DOT-5B	4
DOT-6J	4
DOT-17C	4
DOT-17E	4
DOT-17H	4
DOT-37A	4
DOT-37B	4
DOT-37C	32 inches
DOT-37D	4
Monostress II	6

After drop, the containers remained in the first position for 2 minutes during which time the container and concrete pad were examined for spillage. The containers were turned two revolutions, brought to rest at a different position for one minute and re-examined for spillage. They were removed from the impact area and placed head down and examined again for spillage. Spillage in the first two minutes was listed as a failure.

The results reported in Table 4 indicated that 11 drums and 11 pails failed. The drum failures were noted as leaks in the impact area for Exhibits 20, 16, 50, 54, 68, 141, and leaks at the locking ring joint for Exhibits 132 and 140. The latter drums (132 and 140) were not tested, the leaks having occurred when they were lifted for testing. The failures are illustrated in Figures 15 through 19. Pail failures were noted as a leak at the flex spout of Exhibit 37, severe leaks in the impact area for Exhibits 5, 6, 8, and 57 when dropped from 32 inches, and a slight leak for Exhibit 67 when dropped from 28 inches. Exhibits 41 and 44 leaked after a 4-foot drop, Exhibit 43 leaked after a 42-inch drop, and Exhibits 46 and 47 leaked after a 36-inch drop. Typical failures are illustrated in Figures 20 through 26.

Horizontal Drop Test. The containers were prepared and tested in the same manner using the same height and test equipment as for the diagonal drop test, with the exception that the containers were raised as illustrated in Figure 27 and dropped so that the side seam impacted the base pad. After drop, the container and pad were examined for spillage. The results reported in Table 4 reveal that seven drums and six pails failed the test. Failures for the drums were noted as leaks at the locking ring joint of Exhibits 12, 15, and 73, and Exhibit 39 leaked at the end of the crush pattern. Exhibit 110 leaked at bottom chime, and Exhibits 142 and 143 leaked at the locking ring joint when lifted by the crane to be changed. The latter two drums (142 and 143) were not dropped. Failures of the pails were noted as leaks at the covers of Exhibits 11, 45, 50, 60, 61, and 66. Typical failures are illustrated in Figures 28 through 35.

Powder (Dry Test. Containers were filled to within 2 inches of the normal loading depth and to the gross weight marked on the container with dry sand. Where necessary, materials such as lead shot and empty cans and foamed cushioning materials were used to attain the required weight and till maintain the loading depth. The sand was topped with 2 inches of sodium bicarbonate which is the test material. Each container was closed for test. Containers fitted with the standard closing ring and the lap type of closure ring were torqued to 200 inch-pounds. Beyond this torque the closure ring bent. Containers with 9 inch opening were closed with a special crimping tool. The pails were closed using a 16 lug crimper and a Rieke spout crimper. The containers were tested in the same manner using the same equipment as for the diagonal and horizontal drop tests previously discussed, with the exception that the drop was 4 feet for all containers. After each drop the container was examined for spillage.

The results reported in Table 4 indicate that seven drums and five pails failed. Drum failures were noted as a split chime at the bottom of the container for Exhibit 71, a leak at the end of the crush pattern for Exhibit 158, and a leak at the ring closure for Exhibits 69, 160, and 163. Metal tore 3 inches at the bottom chime for Exhibit 157 and a leak at the ring closure for Exhibit 69. Failures for the 5 gallon pails were noted as leaks at the end of the crush patterns for Exhibits 90, 91, 103, 105, and 116. The failures are illustrated in Figures 36 through 46.

DISCUSSION OF RESULTS

The measured gauge of the containers submitted indicate that the metal used was thicker than that marked on the container. The thickness varied from one to two gauges thicker than that indicated.

The initial failure of the open head 55 gallon drums under the 17H and 17C categories led to changes in the torque requirement for these containers. The torque specified was 50 pound-feet for open head drums; however, industry questioned this torque since it did not use a specific torque when it tested containers as specified in Title 49. The locking ring was tightened until the distance between the bottom of the locking ring and the side of the container was approximately 1/16 inches. The method could hardly be used as a standard. After some discussion between DOT and industry representatives, 800 pound-inches (66.7 pound-feet) was set as the torque for open head drums. Failures still occurred after retorquing to 800 pound-inches. Because of the controversy concerning the torque requirement, industry requested that another group of fourteen 17H 55 gallon drums be dropped. This time the containers would be closed until the distance between the ends of the locking ring was 1/4 inch. They would then be subjected to the diagonal and horizontal tests only. The locking ring was closed to 1/4 inch or less on 11 drums, 17/32 inch on one drum, and two drums were torqued to 800 pound-inches. Six of the 14 drums received for test failed. Four drums which were closed until the distance between the ends of the locking ring was 1/4 inch and one drum torqued to 800 pound-inches leaked at the locking ring joint when lifted to be dropped. The other drum leaked in the crush pattern after being dropped.

Failures noted in the case of the 37A and 37C 5-gallon pails were due to the severity of the tests. Containers under these two categories were to be tested using powder as the contents. The 37A containers were to be dropped from 48 inches and the 37C containers from 32 inches. An attempt was made to determine if these containers could be used to ship liquids. The water-filled pails failed when dropped from the specified height. The drop height was lowered until the containers would pass. The 37A containers failed at the 36 inches height. However, there were not enough containers to determine the height at which they would pass. For the 37C containers, the drop height at which they passed was 28 inches for the diagonal drop and 24 inches for the horizontal drop. A brief resume of the complete air and liquid tests is noted in Table 6.

For the powder test, the open head drums under the 37A category failed because of the closure ring. An attempt to increase the torque resulted in bending of the ring. Therefore, no further attempt was made to tighten the ring. The failure of the 37B drums was attributed to the high pressure used to form the chime, thereby thinning the material in this area. Failure of the 5-gallon pails in the 37A and 37C categories may be due to the excessive weight specified for the containers. No failures were noted for the horizontal drop test. There were not sufficient containers available to determine the height at which the containers would pass the diagonal drop test. A brief resume of the powder test is noted in Table 5.

CONCLUSIONS

It is concluded that the massive failure of the open head drums under categories 17H and 17C drums is attributed to the inadequacy of the locking ring and not the severity of the test. The failures noted for the 37A and 37C 5-gallon pails are believed due to the severity of the test requirements. These pails failed when dropped at the specified height of 48 inches but passed when dropped at heights of 28 and 24 inches for the diagonal and horizontal drop tests, respectively. Such heights are too low to consider their use for shipment of hazardous liquids since the average trailer-bed height is 48 inches. These containers may spill their contents if accidentally knocked from a loading platform or a tail gate.

It is further concluded that the failure of the open head drums under category 37A and evaluated in the powder test is also attributed to the inadequacy of the locking ring. The failure of the pails is due to weight specified for the containers.

RECOMMENDATIONS

It is recommended that the manufacturers be requested to redesign the locking ring to enable the 17H, the open head 17C, and 37A drums to meet the pressure and drop test requirements. It is further recommended that the 37A and 37C pails not be used to ship hazardous liquid or powder materials.

KEY SHEET OF EXHIBITORS

Company

A	Southline Metal Products Company
B	Southeastern Steel Container Company
C	Inland Steel Container
D	Central Can Company, Inc.
E	U.S. Steel Products
F	Trilla Steel Drum Corporation
G	Eastern Steel Barrel Corporation
H	Greif Brothers Corporation
I	Manion Steel Barrel
J	Rheem Manufacturing Company
K	Reliable Steel Drum Company
L	GPF

TABLE 1. DESCRIPTION OF TEST CONTAINERS

Company	DOT Specification	Gauge	Type Closure	Hydrostatic Test	Diagonal Drop	Pneumatic Test	Horizontal Drop	D Powder	Total
A	17E	18	Closed	X	X	X	-	-	3
A	17E	20/18	Closed	X	X	X	-	-	3
A	17E	24	5 Gallons	X	X	X	X	-	4
D	17E	24	5 Gallons	3X	3X	3X	3X	-	12
E	17E	24	5 Gallons	X	X	X	X	-	4
E	17E	18	Closed	X	X	X	X	-	4
E	17E	20/18	Closed	X	X	X	X	-	4
C	17E	18	Closed	X	X	X	X	-	4
C	17E	20/18	Closed	X	X	X	X	-	4
F	17E	18	Closed	2X	X	X	X	-	5
C	17E	24	5 Gallons	X	X	X	X	-	4
I	17E	18	Closed	X	X	X	X	-	4
I	17E	20/18	Closed	X	X	X	X	-	-
J	17E	20/18	Closed	X	X	X	-	-	-
J	17E	18	Closed	X	X	X	-	-	-
J	17E	24	5 Gallons	X	X	X	-	-	3
L	17E	24	5 Gallons	2X	X	X	X	-	5

TABLE 1. DESCRIPTION OF TEST CONTAINERS (Con't)

Company	DOT Specification	Gauge	Type Closure	Hydrostatic Test		Diagonal Drop		Pneumatic Test		Horizontal Drop		D H Powder		Total
				Test		Drop		Test		Drop		Powder		
C	17H	18/16	Opened	X		X		X		X		-		4
E	17H	18/16	Opened	X		X		X		X		-		4
F	17H	18/16	Opened	2X		X		X		X		-		5
I	17H	18/16	Opened	X		X		X		X		-		4
J	17H	18/16	Opened	X		X		X		-		-		3
K	17H	16/18	Opened	2X		X		X		X		-		5
C	17H	18/16	Opened	-		2X		-		2X		-		4
E	17H	18/16	Opened	-		3X		-		3X		-		6
J	17H	18/16	Opened	-		2X		-		2X		-		4
H	37A	22	Open Head	-		X		-		-		2X	2X	5
G	37A	24	Opened	-		-		-		-		3X	2X	5
G	37A	26	Opened	-		-		-		-		3X	2X	5
J	37A	24	Opened 5 Gallons	-		-		-		-		-		11
J	37A	26	Opened 5 Gallons	-		-		-		-		-		10

TABLE 1. DESCRIPTION OF TEST CONTAINERS (Con't)

Company	DOT Specification	Gauge	Type Closure	Hydrostatic Test	Diagonal Drop		Pneumatic Test	Horizontal Drop		D Pouch	H Pouch	Total
B	37C	28/26	5 Gallons	3X	X		3X	X		2X	1X	3
J	37C	28/26	5 Gallons	-	4X		-	3X		X	X	4
C	37C	28/26	5 Gallons	-	2X		-	2X		X	X	6
E	37C	28/26	5 Gallons	-	3X		-	3X		X	X	4
L	37C	28/26	5 Gallons	X	2X		X	2X		2X	2X	10
A	17C	16	Closed	X	X		X	-		-	-	3
C	17C	16	Opened	X	X		X	X		-	-	4
C	17C	16	Closed	X	X		X	X		-	-	4
I	17C	16	Closed	X	X		X	X		-	-	4
J	17C	16	Closed	X	X		X	-		-	-	3
E	17C	16	Closed	X	X		X	X		-	-	4
C	37D	23	Closed	X	X		X	X		-	-	4
C	37D	21/20	Closed	X	X		X	X		-	-	4
D	37B	28	Closed 5 Gallons	3X	1X		3X	X		2X	2X	6
H	37B	25	Small Open 5 Gallons	X	X		X	-		X	X	5
G	37B	24	42 Gallons	-	-		-	-		3X	2X	5
L	37B	28	Closed 5 Gallons	2X	2X		X	X		2X	2X	10

TABLE 1. DESCRIPTION OF TEST CONTAINERS (Con't)

<u>Company</u>	<u>DOT Specification</u>	<u>Gauge</u>	<u>Type Closure</u>	<u>Hydrostatic Test</u>	<u>Diagonal Drop</u>	<u>Pneumatic Test</u>	<u>Horizontal Drop</u>	<u>D H Powder</u>	<u>Total</u>
J	5B	16	Closed	3X	3X	2X	2X	-	10
E	5B	16	Closed	2X	1X	1X	1X	-	5
J	6J	18	Closed	X	X	X	X	X	5
E	5A	14	Closed	2X	X	X	X	-	5
E	5	14	Closed	2X	1X	1X	1X	-	5

TABLE 2. VISUAL EXAMINATION OF 55-GALLON DRUMS

Features	<u>Exhibit Number</u>		
	<u>1 - 3</u>	<u>4 - 6</u>	<u>7 - 9</u> <u>10 - 13</u>
Dents	No	#4 - Flat at chime #6 - 4" dent	#7 - 5" dent #8 - Flat on chime #13 - 3" dent
Paint	Slight Scuff	OK	OK
Inside Surface Treated	No	No	Head Coated
Seam and Chimes	OK	OK	OK
Type Seam	Beam Weld	Beam Weld	Beam Weld
Weld Quality	OK	OK	OK
Condition of Gaskets	OK	OK	OK
Type	Molded Poly-ethylene	Molded Poly-ethylene	Molded Poly-ethylene Head - Molded Rubber Side - Buna
Number of Lugs	N/A	N/A	N/A
Spacing	N/A	N/A	N/A
Depth Convexity	5/8"	5/8"	5/8"
Bolt Size	N/A	N/A	9/16"
Cover Rib	N/A	N/A	Satisfactory
Number of Hoops	Two	Two	Three

TABLE 2. VISUAL EXAMINATION OF 55-GALLON DRUMS (Con't)

<u>Features</u>	<u>Exhibit Number</u>			
	<u>1 - 3</u>	<u>4 - 6</u>	<u>7 - 9</u>	<u>10 - 13</u>
Location of Hoops	Bottom to Top 12" - 12"	Bottom to Top 12" - 12"	Bottom to Top 12" - 12"	Bottom to Top 12" - 12" - 8"
Condition of Hoops	OK	OK	OK	OK
Configuration of Hoops	Rolled	Rolled	Rolled	Rolled
Size of Markings	5/8" and 1"	5/8" and 1"	5/8" and 1"	3/4"
Manufacturer's Identification	S-L 16 55 4 72 DOT 17C	S-L 18 55 72 DOT 17E	S-L 20/18 55 72 DOT 17E	Inland 18/16 55 72 DOT 17H
Overall Diameter	23"	22-3/4"	22-3/4"	24"
Inside Diameter	22-3/8"	22-3/8"	22-3/8"	22-3/8"
Height	35"	35"	35"	34-3/4"
Openings C/C	18"	18"	18"	N/A

TABLE 2. VISUAL EXAMINATION OF 55-GALLON DRUMS (Con't)

Features	Exhibit Number			
	14 - 21	22 - 25	26 - 29	30 - 33
Dents	#19 - 4" dent	No	No	No
Paint	OK	OK	OK	OK
Inside Surface Treated	Head Coated	No	No	No
Seam and Chimes	OK	OK	OK	OK
Type Seam	Beam Weld	Beam Weld	Beam Weld	Beam Weld
Weld Quality	OK	OK	OK	OK
Condition of Gaskets	OK	OK	OK	OK
Type	Head- Molded Rubber Side - Buna	2" - Buna 3/4" - EPT*	Buna	Buna
Number of Lugs	N/A	N/A	N/A	N/A
Spacing	N/A	N/A	N/A	N/A
Depth Convexity	5/8"	5/8"	None	None
Bolt Size	9/16"	N/A	N/A	N/A
Cover Rib	Satisfactory	N/A	N/A	N/A
Number of Hoops	Three	Two	26	26

*Ethylene-Propylene-Terpolymer

TABLE 2. VISUAL EXAMINATION OF 55-GALLON DRUMS (Con')

Features	<u>Exhibit Number</u>			
	<u>14 - 21</u>	<u>22 - 25</u>	<u>26 - 29</u>	<u>30 - 33</u>
Location of Hoops	Bottom to Top 12" - 12" - 8"	Bottom to Top 12" - 12"	1-1/2" Apart	1-1/2" Apart
Condition of Hoops	OK	OK	OK	OK
Configuration of Hoops	Rolled	Rolled	Rolled	Rolled
Size of Markings	3/4"	3/4"	3/4"	3/4"
Manufacturer's Identification	Inland 16 55 72 DOT 17C	Inland 20/18 55 72 DOT 17E	Inland 21/20 55 72 DOT 37D	Inland 23 55 DOT 37D
Overall Diameter	24"	22-3/4"	22-7/8"	22-7/8"
Inside Diameter	22-3/8"	22-3/8"	22-3/8"	22-3/8"
Height	34-3/4"	35"	33-3/4"	33-3/4"
Openings C/C	N/A	17-1/2"	17"	17"

TABLE 2. VISUAL EXAMINATION OF 55-GALLON DRUMS (Con't)

Features	Exhibit Number		
	34 - 37	38 - 40	41 - 44
Dents	No	No	No
Paint	OK	OK	OK
Inside Surface Treated	No	No	No
Seams and Chimes	OK	OK	OK
Type Seam	Beam Weld	Beam Weld	Beam Weld
Weld Quality	OK	OK	OK
Condition of Gaskets	OK	OK	OK
Type	Buna	Head - Molded Rubber 2" - Buna	Buna
Number of Lugs	N/A	N/A	N/A
Spacing	N/A	N/A	N/A
Depth Convexity	5/8"	3/4"	1/4"
Bolt Size	N/A	9/16"	N/A
Cover Rib	N/A	Satisfactory	N/A
Number of Hoops	Two	Three	Two

TABLE 2. VISUAL EXAMINATION OF 55-GALLON DRUMS (Con't)

Features	<u>Exhibit Number</u>			
	<u>34 - 37</u>	<u>38 - 40</u>	<u>41 - 44</u>	<u>45 - 48</u>
Location of Hoops	Bottom to Top 12" - 11"	Bottom to Top 11" - 13" - 8"	Bottom to Top 12" - 12"	Bottom to Top 12" - 12"
Condition of Hoops	OK	OK	OK	OK
Configuration of Hoops	Rolled	Rolled	Rolled	Rolled
Size of Markings	7/8"	7/8"	1"	1"
Manufacturer's Identification	Inland 18 55 72 DOT 17E	MSB 18/16 55 72 5 DOT 17H	USS 16 55 9 72 DOT 17C	USS 20/18 55 72 DOT 17E
	22-7/8"	22-3/4"	22-7/8"	22-3/4"
Overall Diameter	22-3/8"	22-3/8"	22-3/8"	22-3/8"
Inside Diameter	34-3/4"	35-1/4"	34-7/8"	35"
Height	17-1/2"	N/A	18"	18"
Openings C/C				

TABLE 2. VISUAL EXAMINATION OF 55-GALLON DRUMS (Con't)

Features	Exhibit Number		
	49 - 52	53 - 56	57 - 61
Dents	#51 - 2" dent #52 - 3" dent	#56 - 4" dent	#62 - 2" dent
Paint	Slight Scuff	OK	Slight Scuff
Inside Surface Treated	No	No	No
Seams and Chimes	OK	OK	OK
Type Seam	Beam Weld	Beam Weld	Beam Weld
Weld Quality	OK	OK	OK
Condition of Gaskets	OK	OK	Gasket seized to chime, leaving deposit
Type	Buna	Molded Rubber	Sponge
Number of Lugs	N/A	N/A	N/A
Spacing	N/A	N/A	N/A
Depth Convexity	1/4"	1/4"	1/4"
Bolt Size	N/A	9/16"	N/A
Cover Rib	N/A	Satisfactory	Satisfactory
Number of Hoops	Two	Three	Two

TABLE 2. VISUAL EXAMINATION OF 55-GALLON DRUMS (Con't)

Features	<u>Exhibit Number</u>			
	<u>49 - 52</u>	<u>53 - 56</u>	<u>57 - 61</u>	<u>62 - 66</u>
Location of Hoops	Bottom to Top 12" - 12"	Bottom to Top 12" - 12" - 8"	Bottom to Top 12" - 11" - 8"	Bottom to Top 12" - 11"
Condition of Hoops	OK	OK	OK	OK
Configuration of Hoops	Rolled	Rolled	Rolled	Rolled
Size of Markings	1"	1"	3/4"	3/4"
Manufacturer's Identification	USS 18 55 72 DOT 17E	USS 1-4 DOT 17H 18-16 55 72	Trilla 18/16 55 72 DOT 17H	Trilla 18 55 72 DOT 17E
Overall Diameter	22-7/8"	24"	22-7/8"	22-3/4"
Inside Diameter	22-3/8"	22-3/8"	22-7/16"	22-3/8"
Height	35"	34-3/4"	35"	34-1/4"
Openings C/C	18"	N/A	N/A	17-1/2"

TABLE 2. VISUAL EXAMINATION OF 55-GALLON DRUMS (Con't)

Features	Exhibit Number		
	73	74 - 77	78 - 81
Dents	(1) 2" long	No	No
Paint	Slight Scuff	OK	Slight Scuff
Inside Surface Treated	No	No	No
Seam and Chimes	OK	OK	OK
Type Seam	Beam Weld	Beam Weld	Beam Weld
Weld Quality	OK	OK	OK
Condition of Gaskets	OK	OK	OK
Type	Head- Molded Rubber 2" - Buna	Buna	Buna
Number of Lugs	N/A	N/A	N/A
Spacing	N/A	N/A	N/A
Depth Convexity	3/4"	5/8"	5/8"
Bolt Size	9/16"	N/A	N/A
Cover Bib	Satisfactory	N/A	N/A
Number of Hoops	Three	Two	Two
		15 small hoops in top and bottom sections	Two large

TABLE 2. VISUAL EXAMINATION OF 55-GALLON DRUMS (Con't)

Features	Exhibit Number			
	73	74 - 77	78 - 81	82 - 85
Location of Hoops	Bottom to Top 11" - 13" - 8"	Bottom to Top 12" - 12"	Bottom to Top 12" - 11-1/2"	Bottom to Top 12" - 12"
Condition of Hoops	OK	OK	OK	OK
Configuration of Hoops	Rolled	Rolled	Rolled	Rolled
Size of Markings	7/8"	7/8"	7/8"	7/8"
Manufacturer's Identification	MSB 18/16 55 72 5 DOT 17H	MSB 18 55 72 DOT 17E	MSB 20/18 55 72 5 DOT 17E	MSB 16 55 72 5 DOT 17C
Overall Diameter	22-3/4"	22-7/8"	22-7/8"	22-7/8"
Inside Diameter	22-3/8"	22-7/16"	22-1/2"	22-3/8"
Height	35-1/4"	34-7/8"	34-3/4"	34-3/4"
Openings C/C	N/A	17-1/2"	17-1/2"	17-1/2"

TABLE 2. VISUAL EXAMINATION OF 55-GALLON DRUMS (Con't)

<u>Features</u>	<u>Exhibit Number</u>		
	<u>86 - 88</u>	<u>89 - 91</u>	<u>92 - 94</u>
Dents	No	No	No
Paint	#86 - Scuff	OK	OK
Inside Surface Treated	No	No	No
Seam and Chimes	OK	OK	OK
Type Seam	Beam Weld	Beam Weld	Beam Weld
Weld Quality	OK	OK	OK
Condition of Gaskets	OK	OK	OK
Type	Buna	Asbestos	Molded Rubber
Number of Lugs	N/A	N/A	N/A
Spacing	N/A	N/A	N/A
Depth Convexity	5/8"	1/4"	5/8"
Bolt Size	N/A	N/A	2/16"
Cover Bib	N/A	N/A	Satisfactory
Number of Hoops	Two	Two	Three

#97 - 3" dent

Slight Scuff

TABLE 2. VISUAL EXAMINATION OF 55-GALLON DRUMS (Con't)

<u>Features</u>	<u>Exhibit Number</u>			
	<u>86 - 88</u>	<u>89 - 91</u>	<u>92 - 94</u>	<u>95 - 97</u>
Location of Hoops	Bottom to Top 12" - 11"	Bottom to Top 12" - 11"	Bottom to Top 11-1/2" - 11-1/2" - 9"	Bottom to Top 12" - 11-1/2"
Condition of Hoops	OK	OK	OK	OK
Configuration of Hoops	Rolled	Rolled	Rolled	Rolled
Size of Markings	1"	1"	1"	1"
Manufacturer's Identification	Rheem L 18 55 2 72 DOT 17E	Rheem L 20/18 55 2 72 DOT 17E	Rheem 18/16 55 5 72 DOT 17H	Rheem 16 55 5 72 DOT 17C
Overall Diameter	22-7/8"	22-7/8"	22-3/4"	23"
Inside Diameter	22-3/8"	22-3/8"	22-3/8"	22-3/8"
Height	34-7/8"	34-7/8"	35-1/4"	34-7/8"
Openings C/C	17-1/2"	17-1/2"	N/A	17-1/2"

TABLE 2. VISUAL EXAMINATION OF 55-GALLON DRUMS (Con't)

Features	<u>Exhibit Number</u>			
	<u>98 - 101</u>	<u>102 - 111</u>	<u>112 - 116</u>	<u>117 - 121</u>
Dents	No	No	#114 - 4" dent	No
Paint	OK	OK	#114 - Slight Scuff	Scuffed
Inside Surface Treated	No	No	No	No
Seam and Chimes	OK	Reinforced chimes OK	OK	OK
Type Seam	Beam Weld	Beam Weld	Beam Weld	Beam Weld
Weld Quality	OK	OK	OK	OK
Condition of Gaskets	OK	OK	OK	OK
Type	Buna	Molded Poly- ethylene	Buna	Asbestos
Number of Lugs	N/A	N/A	N/A	N/A
Spacing	N/A	N/A	N/A	N/A
Depth Convexity	1/4"	1/4"	1/4"	1/4"
Bolt Size	N/A	N/A	9/16"	N/A
Cover Bib	N/A	N/A	#114 - Flat Spot	N/A
Number of Hoops	Two	Two	Three	Two

TABLE 2. VISUAL EXAMINATION OF 55-GALLON DRUMS (Con't)

Features	Exhibit Number		
	98 - 101	102 - 111	112 - 116
Location of Hoops	Bottom to Top 12" - 11-1/2"	Bottom to Top 12" - 11"	Bottom to Top 12" - 11" - 9"
Condition of Hoops	OK	OK	OK
Configuration of Hoops	Rolled	Rolled	Rolled
Size of Markings	1"	1"	7/8"
Manufacturer's Identification	Rheem 18 55 5 72 DOT 6J	Rheem 16 55 5 72 DOT 5B	RSD 16/18 55 5 72 DOT 17H
Overall Diameter	22-7/8"	23-3/8"	22-7/8"
Inside Diameter	22-3/8"	22-1/8"	22-3/8"
Height	34-3/4"	35"	34-7/8"
Openings C/C	17-1/2"	17-1/2"	18"
			23-1/4"
			22-1/8"
			35"
			17"
			1"
			USS 16 55 4 72 DOT 5B
			Bottom to Top 11-1/2" - 12"

TABLE 2. VISUAL EXAMINATION OF 55-GALLON DRUMS (Con't)

Features	Exhibit Number		
	122 - 126	127 - 131	132 - 135
Dents	No	No	No
Paint	Scuffed	Scuffed	OK
Inside Surface Treated	No	No	Head - Coated
Seam and Chimes	OK	OK	OK
Type Seam	Flash Weld	Flash Weld	Beam Weld
Weld Quality	OK	OK	OK
Condition of Gaskets	OK	OK	OK
Type	Asbestos	Asbestos	Head - Molded Rubber Side - Buna
Number of Lugs	N/A	N/A	N/A
Spacing	N/A	N/A	N/A
Depth Convexity	5/8"	5/8"	5/8"
Bolt Size	N/A	N/A	9/16"
Cover Rib	N/A	N/A	Satisfactory
Number of Hoops	Two	Two	Three

TABLE 2. VISUAL EXAMINATION OF 55-GALLON DRUMS (Con't)

<u>Features</u>	<u>Exhibit Number</u>			
	<u>122 - 126</u>	<u>127 - 131</u>	<u>132 - 135</u>	<u>136 - 139</u>
Location of Hoops	Bottom to Top 11-1/2" - 12-1/2"	Bottom to Top 12" - 12-1/2"	Bottom to Top 12" - 12" - 8"	Bottom to Top 11-1/2" - 11-1/2"
Condition of Hoops	OK	OK	OK	OK
Configuration of Hoops	T-Bar	T-Bar	Rolled	Rolled
Size of Markings	1"	1"	3/4"	1"
Manufacturer's Identification	USS 14 55 72 DOT 5A	USS 14 55 72 DOT 5	Inland 18/16 55 72 DOT 17H	Rheem 18/16 55 5 72 DOT 17H
Overall Diameter	23-1/8"	23-1/8"	24"	22-3/4"
Inside Diameter	22"	22"	23-3/8"	22-3/8"
Height	35-7/8"	35-5/8"	34-3/4"	35-1/4"
Openings C/C	17"	17"	N/A	N/A

TABLE 2. VISUAL EXAMINATION OF 55-GALLON DRUMS (Con't)

<u>Exhibit Number</u> 140 - 145		<u>Exhibit Number</u> 140 - 145	
<u>Features</u>		<u>Features</u>	
Dents	No	Cover Bib	Satisfactory
Paint	OK	Number of Hoops	Three
Inside Surface Treated	No	Location of Hoops	Bottom to Top 12" - 12" - 8"
Seam and Chimes	OK	Condition of Hoops	OK
Type	Beam Weld	Configuration of Hoops	Rolled
Weld Quality	OK	Size of Markings	1"
Condition of Gaskets	OK	Manufacturer's Identification	USS 18/16 55 72 DOT 17H
Type	Molded Rubber	Overall Diameter	24"
Number of Lugs	N/A	Inside Diameter	22 3/8"
Spacing	N/A	Height	34-3/4"
Depth Convexity	1/4"	Openings C/C	N/A
Bolt Size	9/16"		

TABLE 2. VISUAL EXAMINATION OF 5-GALLON DRUMS

Features	<u>Exhibit Number</u>			
	<u>1 - 4</u>	<u>5 - 11</u>	<u>12 - 23</u>	<u>24 - 27</u>
Dents	#2, 3, 4, - Two dents each	No	#17 - 4" dent	No
Paint	OK	OK	OK	OK
Inside Surface Treated	No	No	No	No
Seam and Chimes	OK	OK	OK	OK
Type Seam	Beam Weld	Beam Weld	Beam Weld	Beam Weld
Weld Quality	OK	OK	OK	OK
Condition of Gaskets	OK	OK	OK	OK
Type	Fibre	Flowed-In Sponge	Flexible Spout	Flexible Spout
Number of Lugs	N/A	16	N/A	N/A
Spacing	N/A	2-1/4" C/C	N/A	N/A
Depth Convexity	None	None	None	None
Bolt Size	N/A	N/A	N/A	N/A
Cover Bib	N/A	N/A	N/A	N/A
Number of Hoops	None	Two	None	None

TABLE 2. VISUAL EXAMINATION OF 5-GALLON DRUMS (Con't)

Features	<u>Exhibit Number</u>			
	<u>1 - 4</u>	<u>5 - 11</u>	<u>12 - 23</u>	<u>24 - 27</u>
Location of Hoops	N/A	Bottom to Top 9-1/2" - 3"	N/A	N/A
Condition of Hoops	N/A	OK	N/A	N/A
Configuration of Hoops	N/A	Rolled	N/A	N/A
Size of Markings	1-3/4" and 3/4"	5/8" and 1/2"	7/16" and 1/2"	1/2" and 3/4"
Manufacturer's Identification	Southline 24 5 72 DOT 17E	Sesco 28/26 5 72 DOT 37C 80	Central Can Company 24 5 72 DOT 17E	USS 24 5 72 DOT 17E
Overall Diameter	11-3/8"	11-3/4"	11-3/8"	11-3/8"
Inside Diameter	11-1/8"	11-1/4"	11-3/16"	11-1/8"
Height	14"	13-1/2"	13-3/4"	14"
Openings C/C	N/A	N/A	N/A	N/A

TABLE 2. VISUAL EXAMINATION OF 5-GALLON DRUMS (Con't)

Features	<u>Exhibit Number</u>			
	<u>28 - 35</u>	<u>36 - 39</u>	<u>40 - 42</u>	<u>43 - 49</u>
Dents	No	No	No	No
Paint	OK	OK	OK	OK
Inside Surface Treated	No	No	No	No
Seam and Chimes	OK	OK	OK	OK
Type Seam	Beam Weld	Beam Weld	Beam Weld	Beam Weld
Weld Quality	OK	OK	OK	OK
Condition of Gaskets	OK	OK	OK	OK
Type	Flexible Spout	Flexible Spout	Flowed In Sponge	Flowed In Sponge
Number of Lugs	N/A	N/A	16	16
Spacing	N/A	N/A	2-1/4" C/C	2-1/4" C/C
Depth Convexity	None	None	None	None
Bolt Size	N/A	N/A	N/A	N/A
Cover Bib	N/A	N/A	N/A	N/A
Number of Hoops	None	None	Two	Two

TABLE 2. VISUAL EXAMINATION OF 5-GALLON DRUMS (Con't)

<u>Features</u>	<u>Exhibit Number</u>		
	<u>28 - 35</u>	<u>36 - 39</u>	<u>40 - 42</u>
Location of Hoops	N/A	N/A	Bottom to Top 9-1/2" - 3"
Condition of Hoops	N/A	N/A	OK
Configuration of Hoops	N/A	N/A	Rolled
Size of Markings	1/2" and 5/8"	1/2"	1/2"
Manufacturer's Identification	Central Can Co. 28 5 72 DOT 37B 60	Inland 24 5 72 DOT 17E	Rheem 26 5 72 DOT 37A
Overall Diameter	11-3/8"	11-3/8"	11-3/8"
Inside Diameter	11-3/16"	11-1/8"	11-1/8"
Height	13-3/4"	14"	13-3/4"
Openings C/C	N/A	N/A	N/A

TABLE 2. VISUAL EXAMINATION OF 5-GALLON DRUMS (Con't)

Features	<u>Exhibit Number</u>			
	<u>50 - 52</u>	<u>53 - 55</u>	<u>56 - 62</u>	<u>63 - 67</u>
Dents	No	No	No	No
Paint	OK	OK	OK	OK
Inside Surface Treated	No	No	No	No
Seam and Chimes	OK	OK	OK	OK
Type Seam	Beam Weld	Beam Weld	Beam Weld	Beam Weld
Weld Quality	OK	OK	OK	OK
Condition of Gaskets	OK	OK	OK	OK
Type	Flowed-In Sponge	Flexible Spout	Flow-In Sponge	Flowed-In Sponge
Number of Lugs	16	N/A	16	16
Spacing	2-1/4" C/C	N/A	2-1/4" C/C	2-1/4" C/C
Depth Convexity	None	None	None	None
Bolt Size	N/A	N/A	N/A	N/A
Cover Bib	N/A	N/A	N/A	N/A
Number of Hoops	Two	None	Two	Two

TABLE 2. VISUAL EXAMINATION 5-GALLON DRUMS (Con't)

Features	<u>Exhibit Number</u>		
	<u>53 - 52</u>	<u>53 - 55</u>	<u>56 - 62</u> <u>63 - 67</u>
Location of Hoops	Bottom to Top 9-1/2" - 3"	N/A	Bottom to Top 9-1/2" - 3"
Condition of Hoops	OK	N/A	OK
Configuration of Hoops	Rolled	N/A	Rolled
Size of Markings	1/2"	1/2"	1/2"
Manufacturer's Identification	Rheem 24 5 72 DOT 37A	Rheem 24 5 72 DOT 17E	Inland 28/26 5 72 DOT 37C
Overall Diameter	11-1/4"	11-3/8"	11-3/4"
Inside Diameter	11'1/8"	11'1/8"	11'1/4"
Height	13-3/4"	13-3/4"	13-3/4"
Openings C/C	N/A	N/A	N/A

TABLE 2. VISUAL EXAMINATION OF 5-GALLON DRUMS (Con't)

Features	<u>Exhibit Number</u>		
	<u>68 - 72</u>	<u>73 - 78</u>	<u>79 - 84</u>
Dents	No	No	No
Paint	OK	OK	OK
Inside Surface Treated	No	No	No
Seam and Chimes	OK	OK	OK
Type Seam	Beam Weld	Beam Weld	Beam Weld
Weld Quality	OK	OK	OK
Condition of Gaskets	OK	OK	OK
Type	Flowed-In Sponge	Flowed-In Sponge	Flexible Spout
Number of Lugs	16	16	N/A
Spacing	2-1/4" C/C	2-1/4" C/C	N/A
Depth Convexity	None	None	None
Bolt Size	N/A	N/A	N/A
Cover Bib	N/A	N/A	N/A
Number of Hoops	Two	Two	None

TABLE 2. VISUAL EXAMINATION OF 5-GALLON DRUMS (Con't)

<u>Features</u>	<u>68 - 72</u>		<u>73 - 78</u>		<u>Exhibit Number</u>		<u>85 - 89</u>	
	Bottom to Top 9-1/2" - 3		Bottom to Top 9-1/2" - 3		79 - 84			
Location of Hoops	OK		OK		N/A		N/A	
Condition of Hoops	OK		OK		N/A		N/A	
Configuration of Hoops	Rolled		Rolled		N/A		N/A	
Size of Markings	1/2" and 3/4"		1/2"		1/2"		1/2"	
Manufacturer's Identification	USS 28/26 5 72 DOT 37C		GPF 28/26 5 72 DOT 37C		GPF 28 5 72 DOT 37B		GPF 24 5 72 DOT 17E	
Overall Diameter	11-3/4"		11-3/4"		11-3/8"		11-3/8"	
Inside Diameter	11-1/4"		11-1/4"		11-3/16"		11-1/8"	
Height	13-3/4"		13-3/4"		13-3/4"		14"	
Openings C/C	N/A		N/A		N/A		N/A	

TABLE 3. Measured Gauges of 55-Gallon Drums and 5-Gallon Pails

Exhibit	Measured Thickness				Manufacturer's Gauge
	Body		Head		
	Inches	AWG	Inches	AWG	
Drums					
6	.0464	17	.0497	16	18
13	.0474	17	.0548	15	18/16
18	.0575	15	.0468	16	16
27	.0483	16	.0337	19	21/20
36	.0537	16	.0425	18	18
45	.0326	20	.0451	17	20/18
60	.0468	17	.0536	16	18/16
84	.0545	15	.0497	16	16
89	.0330	20	.0507	16	20/18
98	.0483	16	.0465	17	18
115	.0451	17	.0555	15	16/18
118	.0537	16	.0500	16	16
125	.0712	13	.0704	13	14
127	.0725	13	.0702	13	14
Pails					
19	.0213	23	.0228	23	24
24	.0228	23	.0229	23	24
33	.0154	26	.0158	26	28
48	.0164	26	.0166	26	26
70	.0139	27	.0163	26	28/26
76	.0132	28	.0183	25	28/26
88	.0245	22	.0225	23	24

TABLE 4. TABLE OF RESULTS

Exhibit	Company	DOT Specification	CFR Section Title 49	Gauge	Size	Type Closure	Test	Test Requirement	Result	Remarks	Figure
1	A	17C	178.115	16	55	Closed	Hydrostatic	40 PSIG	Pass	Crowning of both heads - radial stress lines, top and bottom chimes uncurled 4 inches from 2-inch bung.	
2	A	17C	178.115	16	55	Closed	Diagonal	4 FT	Pass	No leaks - distortion at 2-inch bung area.	
3	A	17C	178.115	16	55	Closed	Pneumatic	15 PSIG	Pass	No distortion.	
4	A	17E	178.116	18	55	Closed	Hydrostatic	15 PSIG	Pass	Slight radial stress lines top and bottom.	
5	A	17E	178.116	18	55	Closed	Diagonal	4 FT	Pass		
6	A	17E	178.116	18	55	Closed	Pneumatic	7 PSIG	Pass		
7	A	17E	178.116	20/18	55	Closed	Hydrostatic	15 PSIG	Pass	Excessive radial stress on top and bottom.	
8	A	17E	178.116	20/18	55	Closed	Diagonal	4 FT	Pass		
9	A	17E	178.116	20/18	55	Closed	Pneumatic	7 PSIG	Pass		
10	C	17H	178.118	18/16	55	Opened	Diagonal	4 FT	Fail	Severe leak at impact area.	

TABLE 4. TABLE OF CONTENTS (Con't)

Exhibit	Company	DOT Specification	CPR Section Title 49	Gauge	Size	Type Closure	Test	Test Requirement	Result	Remarks	Figure
11	C	17H	178.118	18/16	55	Open	Hydrostatic	15 PSIG	Pass	Retorque to 800 in.lb. Slight crowning and excessive radial lines top.	
12	C	17H	178.118	18/16	55	Open	Horizontal	4 FT.	Fail	Leak at locking ring joint.	28
13	C	17H	178.118	18/16	55	Open	Pneumatic	7 PSIG	Pass	Very slight crowning top and bottom.	
14	C	17C	178.115	16	55	Open	Hydrostatic	20 PSIG	Fail	Retorque to 800 in.lb. Leak at 18 lb. at locking ring joint.	4
15	C	17C	178.115	16	55	Open	Horizontal	4 FT	Fail	Retorqued to 800 in.lb. Locking ring near bottom.	29
16	C	17C	178.115	16	55	Open	Diagonal	4 FT.	Fail	Retorqued to 800 in.lbs. Leak at end of crush pattern.	16
17	C	17C	178.115	16	55	Open	Pneumatic	15 PSIG	Pass	Retorqued to 800 in.lb. Slight crowning and radial lines top and bottom.	
18	C	17C	178.115	16	55	Closed	Pneumatic	15 PSIG	Pass	Slight radial stress lines top and bottom heads.	
19	C	17C	178.115	16	55	Closed	Diagonal	4 FT	Pass	Leak at distorted chime after two minutes.	
20	C	17C	178.115	16	55	Closed	Hydrostatic	40 PSIG	Pass	Excess crowning and radial lines top and bottom.	

TABLE 4. TABLE OF RESULTS (Con't)

Exhibit	Company	DOT Specification	CFR Section Title 49	Gauge	Size	Type Closure	Test	Test Requirement	Result	Remarks	Figure
21	C	17C	178.115	16	55	Closed	Horizontal	4 FT	Pass		
22	C	17E	178.116	20/18	55	Closed	Diagonal	4 FT	Pass	No leaks. Distortion at 2-inch bung.	
23	C	17E	178.116	20/18	55	Closed	Horizontal	4 FT	Pass	Drum humped on top at rest position.	
24	C	17E	178.116	20/18	55	Closed	Hydrostatic	15 PSIG	Pass	Excessive crowning top and bottom with radial lines.	
25	C	17E	178.116	20/18	55	Closed	Pneumatic	7 PSIG	Pass	Very slight crowning. Slight radial stress lines top and bottom.	
26	C	37D	178.137	21/20	55	Closed	Diagonal	4 FT	Pass	Dropped from crane about 8 feet on corner of cement. No leak. Retest at 6 feet on diagonal.	
27	C	37D	178.137	21/20	55	Closed	Hydrostatic	15 PSIG	Pass	Slight crowning and radial lines top only.	
28	C	37D	178.137	21/20	55	Closed	Pneumatic	7 PSIG	Pass	Slight crowning and very slight radial lines top and bottom.	
29	C	37D	178.137	21/20	55	Closed	Horizontal	4 FT	Pass	Top sagged. Reinforced chime separated slightly.	
30	C	37D	178.137	23	55	Closed	Horizontal	4 FT	Pass	Top sagged. Reinforced chime separated slightly.	

TABLE 4. TABLE OF RESULTS (Con't)

Exhibit	Company	DOT Specification	CFR Section Title 49	Gauge	Size	Type Closure	Test	Test Requirement	Result	Remarks	Figure
31	C	37D	178.137	23	55	Closed	Diagonal	4 FT.	Pass		
32	C	37D	178.137	23	55	Closed	Hydrostatic	15 PSIG	Pass	Radial lines at bottom.	
33	C	37D	178.137	23	55	Closed	Pneumatic	7 PSIG	Pass		
34	C	17E	178.116	18	55	Closed	Diagonal	4 FT	Pass	Leak at third attitude.	
35	C	17E	178.116	18	55	Closed	Horizontal	4 FT	Pass		
36	C	17E	178.116	18	55	Closed	Hydrostatic	15 PSIG	Pass	Excessive crowning radial lines top and bottom.	
37	C	17E	178.116	18	55	Closed	Pneumatic	7 PSIG	Pass		
38	I	17H	178.118	18/16	55	Opened	Hydrostatic	15 PSIG	Fail	Massive leak at closure joint 11 lb.	5
39	I	17H	178.118	18/16	55	Opened	Horizontal	4 FT	Fail	Torque 800 in-lb. leak at end of crush pattern.	30
40	I	17H	178.118	18/16	55	Opened	Pneumatic	7 PSIG	Pass	Very slight crowning.	
41	E	17C	178.115	16	55	Closed	Hydrostatic	40 PSIG	Pass	Excessive radial lines crowning top and bottom.	
42	E	17C	178.115	16	55	Closed	Diagonal	4 FT	Pass	No leak initially - leak at second altitude at side.	

TABLE 4. TABLE OF RESULTS (Con't)

Exhibit	Company	DOT Specification	CFR Section Title 49	Gauge	Size	Type Closure	Test	Test Requirement	Result	Remarks	Figure
43	E	17C	178.115	16	55	Closed	Pneumatic	15 PSIG	Pass	Slight crowning top and bottom. Slight radial lines top and bottom.	
44	E	17C	178.115	16	55	Closed	Horizontal	4 FT	Pass	Slight puff at 2-inch bung. on impact.	
45	E	17E	178.116	20/18	55	Closed	Hydrostatic	15 PSIG	Pass	Moderate radial lines, crowning top and bottom.	
46	E	17E	178.116	20/18	55	Closed	Diagonal	4 FT	Pass	Leak at chime in impact area after two minutes and first roll.	
47	E	17E	178.116	20/18	55	Closed	Pneumatic	7 PSIG	Pass	Very slight radial stress bottom head.	
48	E	17E	178.116	20/18	55	Closed	Horizontal	4 FT	Pass	Drum humped on top.	
49	E	17E	178.116	18	55	Closed	Hydrostatic	15 PSIG	Drum Pass	Radial lines top and bottom. Leak at 2-inch bung due to gasket gathering. Retest for gasket. Pass.	
50	E	17E	178.116	18	55	Closed	Diagonal	4 FT.	Fail	Leak in impact area at chime.	17
51	E	17E	178.116	18	55	Closed	Pneumatic	7 PSIG	Pass		
52	E	17E	178.116	18	55	Closed	Horizontal	4 FT	Pass	Slight puff at both 3/4-inch and 2-inch bung.	

TABLE 4. TABLE OF RESULTS (Con't)

<u>Exhibit</u>	<u>Company</u>	<u>DOT Specification</u>	<u>CFR Section Title 49</u>	<u>Gauge</u>	<u>Size</u>	<u>Type Closure</u>	<u>Test</u>	<u>Test Requirement</u>	<u>Result</u>	<u>Remarks</u>	<u>Figure</u>
53	E	17H	178.118	18/16	55	Opened	Hydrostatic	15 PSIG	Fail	Crowning top and bottom head. Leak at locking ring joint area. Radial stress lines. Leak stopped after 2 minutes.	6
54	E	17H	178.118	18/16	55	Opened	Diagonal	4 FT	Fail	Leak at initial contact area - leak at 90 degrees from contact after 2 minutes.	18
55	E	17H	178.118	18/16	55	Opened	Pneumatic	7 PSIG	Pass		
56	E	17H	178.118	18/16	55	Opened	Horizontal	4 FT	Pass	Retorque 800 in.lb. Slight puff on impact.	
57	F	17H	178.118	18/16	55	Opened	Hydrostatic	15 PSIG	Fail	Slight crowning bottom and top head. Leak at closure joint in 2.5 minutes.	
58	F	17H	178.118	18/16	55	Opened	Hydrostatic	15 PSIG	Fail	Slight crowning bottom head. Very slight radial stress at top. Slow leak at locking ring joint.	
59	F	17H	178.118	18/16	55	Opened	Diagonal	4 FT	Pass	Very slight puff of H ₂ O at impact. No leak thereafter.	
60	F	17H	178.118	18/16	55	Opened	Pneumatic	7 PSIG	Pass		
61	F	17H	178.118	18/16	55	Opened	Horizontal	4 FT	Pass	Torque 800 in-lbs.	

TABLE 4. TABLE OF RESULTS (Con't)

Exhibit	Company	DOT Specification	CFR Section Title 49	Gauge	Size	Type Closure	Test	Test Requirement	Result	Remarks	Figure
62	F	17E	178.116	18	55	Closed	Hydrostatic	15 PSIG	Pass	Top head slight radial lines - bottom head slight crowning.	
63	F	17E	178.116	18	55	Closed	Hydrostatic	15 PSIG	Pass	Slight radial lines top and bottom.	
64	F	17E	178.116	18	55	Closed	Diagonal	4 FT	Pass		
65	F	17E	178.116	18	55	Closed	Pneumatic	7 PSIG	Pass		
66	F	17E	178.116	18	55	Closed	Horizontal	4 FT	Pass	Very slight puff of H ₂ O at impact. Drum humped at top side.	
*67	H	37A	178.131	22	55	Opened	Diagonal	4 FT	Fail	Leaked at end of crush pattern.	
68	H	37A	178.131	22	55	Opened	Diagonal	4 FT	Fail	Very severe leak. Drum emptied in seconds.	
*69	H	37A	178.131	22	55	Opened	Diagonal	4 FT	Fail	Leaked at ring closure before dropping. Bolt ring tried, 100 in-lb. torque. Failed	
*70	H	37B	178.132	26	55	9" Open	Diagonal	4 FT	Pass	Slight dusting in second attitude.	36
*71	H	37B	178.132	26	55	9" Open	Diagonal	4 FT	Fail	Bottom and top seam split.	
*72	H	37B	178.132	26	55	9" Open	Diagonal	4 FT			
73	I	17H	178.118	18/16	55	Opened	Horizontal	4 FT	Fail	Reverqued to 200 in-lb. torque on impact at closure joint.	

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TABLE 4. TABLE OF RESULTS (Con't)

Exhibit	Company	DOT Spec- ification	CFR Section Title 49	Gauge	Size	Type Closure	Test	Test Re- quirement	Re- sult	Remarks	Figure
74	I	17E	178.116	18	55	Closed	Hydro- static	15 PSIG	Pass	Crowning and radial lines top and bottom.	
75	I	17E	178.116	18	55	Closed	Diagonal	4 FT	Pass		
76	I	17E	178.116	18	55	Closed	Pneumatic	7 PSIG	Pass		
77	I	17E	178.116	18	55	Closed	Horizontal	4 FT	Pass		
78	I	17E	178.116	20/18	55	Closed	Hydro- static	15 PSIG	Pass	Crowning top and bottom. Also radial lines.	
79	I	17E	178.116	20/18	55	Closed	Diagonal	4 FT	Pass	Sharp creases in middle before drop. No leak.	
80	I	17E	178.116	20/18	55	Closed	Pneumatic	7 PSIG	Pass		
81	I	17E	178.116	20/18	55	Closed	Horizontal	4 FT	Pass		
82	I	17C	178.115	16	55	Closed	Hydro- static	40 PSIG	Pass	Excess crowning bottom and top. Radial stress lines.	
83	I	17C	178.115	16	55	Closed	Diagonal	4 FT	Pass	Leak at third attitude.	
84	I	17C	178.115	16	55	Closed	Pneumatic	15 PSIG	Pass	Slight radial lines top and bottom.	
85	I	17C	178.115	16	55	Closed	Horizontal	4 FT	Pass		

TABLE 4. TABLE OF RESULTS (Con't)

Exhibit	Company	DOT Specification	CFR Section Title 49	Gauge	Size	Type Closure	Test	Test Requirement	Result	Remarks	Figure
86	J	17E	178.116	18	55	Closed	Hydro-static	15 PSIG	Pass	Slight crowning, radial lines top and bottom.	
87	J	17E	178.116	18	55	Closed	Diagonal	4 FT	Pass	Leak at second attitude.	
88	J	17E	178.116	18	55	Closed	Pneumatic	7 PSIG	Pass		
89	J	17E	178.116	20/18	55	Closed	Hydro-static	15 PSIG	Pass	Slight crowning, radial lines top and bottom.	
90	J	17E	178.116	20/18	55	Closed	Diagonal	4 FT	Pass		
91	J	17E	178.116	20/18	55	Closed	Pneumatic	7 PSIG	Pass		
92	J	17H	178.118	18/16	55	Opened	Hydro-static	15 PSIG	Fail	Very slight leak at ring closure joint - 800 in.lbs. torque.	
93	J	17H	178.118	18/16	55	Opened	Diagonal	4 FT	Pass	Torque 800 in.lbs.	
94	J	17H	178.118	18/16	55	Opened	Pneumatic	7 PSIG	Pass	Very slight crowning and radial lines.	
95	J	17C	178.115	16	55	Closed	Hydro-static	40 PSIG	Pass	Excessive crowning. Radial lines top and bottom.	
96	J	17C	178.115	16	55	Closed	Diagonal	4 FT	Pass		
97	J	17C	178.115	16	55	Closed	Pneumatic	15 PSIG	Pass	Very slight radial lines, crowning top and bottom.	

TABLE 4. TABLE OF RESULTS (Con't)

<u>Exhibit</u>	<u>Company</u>	<u>DOT Spec- ification</u>	<u>CFR Section Title 49</u>	<u>Gauge</u>	<u>Size</u>	<u>Type Closure</u>	<u>Test</u>	<u>Test Re- quirement</u>	<u>Re- sults</u>	<u>Remarks</u>	<u>Figure</u>
98	J	6J	178.100	18	55	Closed	Hydro- static	15 PSIG	Pass	Crowning top and bottom head. Radial stress lines.	
99	J	6J	178.100	18	55	Closed	Diagonal	4 FT	Fail	Leak at the end of crush pattern.	
100	J	6J	178.100	18	55	Closed	Pneumatic	7 PSIG	Pass		
101	J	6J	178.100	18	55	Closed	Horizontal	4 FT	Pass		
102	J	5B	178.82	16	55	Closed	Hydro- static	40 PSIG	Pass	Crowning top and bottom. Radial stress lines.	
103	J	5B	178.82	16	55	Closed	Hydro- static	40 PSIG	Pass	Very slight crowning. Slight radial lines top and bottom.	
104	J	5B	178.82	16	55	Closed	Hydro- static	40 PSIG	Pass		
105	J	5B	178.82	16	55	Closed	Diagonal	4 FT	Pass	Slight distortion.	
106	J	5B	178.82	16	55	Closed	Diagonal	4 FT	Pass	Very little distortion.	
107	J	5B	178.82	16	55	Closed	Diagonal	4 FT	Pass	Very little distortion. Re- test at 6 feet on bottom. Pass. Retest at 8 feet on bottom. Reinforced ring broke loose one side. No leak.	
108	J	5B	178.82	16	55	Closed	Pneumatic	7 PSIG	Pass		

TABLE 4. TABLE OF RESULTS (Con't)

Exhibit	Company	DOT Specification	CFR Section Title 49	Gauge	Size	Type Closure	Test	Test Requirement	Result	Remarks	Figure
109	J	5B	178.82	16	55	Closed	Pneumatic	7 PSIG	Pass		
110	J	5B	178.82	16	55	Closed	Horizontal	4 FT	Fail	Puff at bottom head. Very slow leak at bottom head.	
111	J	5B	178.82	16	55	Closed	Horizontal	4 FT	Pass	Very little distortion.	
112	K	17H	178.118	16/18	55	Opened	Hydrostatic	15 PSIG	Fail	Massive leak at ring closure joint, 11 psi - 800 in.lbs. torque.	7
113	K	17H	178.118	16/18	55	Opened	Hydrostatic	15 PSIG	Fail	Leak at closure joint at 13-1/2 PSIG - torqued to 800 in.lbs.	
114	K	17H	178.118	16/18	55	Opened	Diagonal	4 FT	Void	Cover had flat spot from being dropped. No seal. Did not test.	
115	K	17H	178.118	16/18	55	Opened	Pneumatic	7 PSIG	Pass	800 in.lbs. torque.	
116	K	17H	178.118	16/18	55	Opened	Horizontal	4 FT	Pass	Slight puff at impact.	
117	E	5B	178.82	16	55	Closed	Hydrostatic	40 PSIG	Pass	Slight crowning.	
118	E	5B	178.82	16	55	Closed	Hydrostatic	40 PSIG	Pass	Very slight crowning and radial lines.	
119	E	5B	178.82	16	55	Closed	Diagonal	4 FT	Pass	Very little distortion.	

TABLE 4. TABLE OF RESULTS (Con't)

Exhibit	Company	DOT Specification	CFR Section Title 49	Gauge	Size	Type Closure	Test	Test Requirement	Result	Remarks	Figure
120	E	5B	178.82	16	55	Closed	Pneumatic	15 PSIG	Pass	Very little affect.	
121	E	5B	178.82	16	55	Closed	Horizontal	4 FT	Pass	Very little distortion.	
122	E	5A	178.81	14	55	Closed	Hydro-static	80 PSIG	Drum Pass	Leak at 76 PSIG at closure torque 410 in.lb. Radial lines medium crowning.	
123	E	5A	178.81	14	55	Closed	Hydro-static	80 PSIG	Pass	Slight crowning and radial lines.	
124	E	5A	178.81	14	55	Closed	Diagonal	6 FT	Pass		
125	E	5A	178.81	14	55	Closed	Pneumatic	15 PSIG	Pass	Very little effect.	
126	E	5A	178.81	14	55	Closed	Horizontal	6 FT	Pass		
127	E	5	178.80	14	55	Closed	Hydro-static	40 PSIG	Pass	Slight crowning, radial lines top only.	
128	E	5	178.80	14	55	Closed	Hydro-static	40 PSIG	Fail	Leak from 2-inch bung threaded adapter at 0 pressure.	8
129	E	5	178.80	14	55	Closed	Diagonal	4 FT	Pass		
130	E	5	178.80	14	55	Closed	Pneumatic	15 PSIG	Pass	Slight crowning and radial lines.	
131	E	5	178.80	14	55	Closed	Horizontal	4 FT	Pass		

TABLE 4. TABLE OF RESULTS (Con't)

Exhibit	Company	DOT Specification	CFR Section Title 49	Gauge	Size	Type Closure	Test	Test Requirement	Result	Remarks	Figure
132	C	17H	178.118	18/16	55	Opened	Diagonal	4 FT	Fail	No torque value. Ring tightened to 3/16 inch at closure joint. Leak at closure upon lifting drum. No drop	
133	C	17H	178.118	18/16	55	Opened	Horizontal	4 FT	Pass	No torque value. Ring tightened to 3/16 inch at closure joint.	
134	C	17H	178.118	18/16	55	Opened	Diagonal	4 FT	Pass	No torque value. Ring tightened to 11/16 inch at closure joint. Puff at impact area. Leak at third attitude.	
135	C	17H	178.118	18/16	55	Opened	Horizontal	4 FT	Pass	No torque value. Ring tightened to 3/16 inch at closure joint.	
136	J	17H	178.118	18/16	55	Opened	Diagonal	4 FT	Pass	No torque value. Ring tightened to 1/4 inch at closure joint.	
137	J	17H	178.118	18/16	55	Opened	Diagonal	4 FT	Pass	No torque value. Ring tightened to 1/4 inch at closure joint. No leak.	
138	J	17H	178.118	18/16	55	Opened	Horizontal	4 FT	Pass	No torque value. Ring tightened to 1/4 inch at closure joint.	
139	J	17H	178.118	18/16	55	Opened	Horizontal	4 FT	Pass	No torque value. Ring tightened to 7/32 inch at closure joint.	
140	E	17H	178.118	18/16	55	Opened	Diagonal	4 FT	Fail	No torque value. Ring tightened to 3/16 inch at closure joint. Leak at closure upon lifting drum. No drop.	

TABLE 4. TABLE OF RESULTS (Con't)

<u>Exhibit</u>	<u>Company</u>	<u>DOT Spec- ification</u>	<u>CFR Section Title 49</u>	<u>Gauge</u>	<u>Size</u>	<u>Type Closure</u>	<u>Test</u>	<u>Test Re- quirement</u>	<u>Re- sult</u>	<u>Remarks</u>	<u>Figure</u>
141	E	17H	178.118	18/16	55	Opened	Diagonal	4 FT	Fail	No torque value. Ring tightened to 3/16 inch at closure joint. Very slow leak at crush pattern.	19
142	E	17H	178.118	18/16	55	Opened	Horizontal	4 FT	Fail	No torque value. Ring tightened to 1/4 inch at closure joint. Leak at closure when drum inverted. No drop.	
143	E	17H	178.118	18/16	55	Opened	Horizontal	4 FT	Fail	Torque 800 in. lbs. Very slight leak at ring closure upon lifting drum. No drop.	
144	E	17H	178.118	18/16	55	Opened	Diagonal	4 FT	Pass	Torque 800 in. lbs. Puff at impact.	
145	E	17H	178.118	18/16	55	Opened	Horizontal	4 FT	Fail	No torque value. Ring tightened to 17/32 inch. This is an old ring from drum number 55. Leaks when lifted from ground.	
*146	G	37B	178.132	24	42	Opened	Diagonal	4 FT	Pass	300 lbs. 9-in. opening. No leaks.	
*147	G	37B	178.132	24	42	"	Diagonal	4 FT	Pass	300 lbs. 9-in. opening. No leaks.	
*148	G	37B	178.132	24	42	"	Diagonal	4 FT	Pass	300 lbs. 9-in. opening. No leaks.	
*149	G	37B	178.132	24	42	"	Horizontal	4 FT	Pass	300 lbs. 9-in. opening. No leaks.	

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TABLE 4. TABLE OF RESULTS (Con't)

Exhibit	Company	DOT Specifi- cation	CFR Section Title 49	Gauge	Size	Type Closure	Test	Test Re- quirement	Re- sult	Remarks	Figure
*150	G	37B	178.132	24	42	Opened	Horizontal	4 FT	Pass	300 lbs. 9-in. opening. No leaks.	
*151	G	37A	178.131	24	55	Opened	Diagonal	4 FT	Pass	350 lbs. torque 200 in.lbs. No leaks.	
*152	G	37A	178.131	24	55	Opened	Diagonal	4 FT	Pass	350 lbs. torque 200 in.lbs. Leak at second attitude at both ends of crush.	
*153	G	37A	178.131	24	55	Opened	Diagonal	4 FT	Pass	350 lbs. torque 200 in.lbs. Puff at impact. Slight sift upon rolling.	
*154	G	37A	178.131	24	55	Opened	Horizontal	4 FT	Pass	350 lbs. torque 200 in.lbs. No leaks.	
*155	G	37A	178.131	24	55	Opened	Horizontal	4 FT	Pass	350 lbs. torque 200 in.lbs. Ring closure placed at end of crush before drop. No leaks.	
*156	H	37B	178.132	26	55	Opened	Horizontal	4 FT	Not Tested	275 lbs., 9-in. opening.	
*157	H	37B	178.132	26	55	Opened	Horizontal	4 FT	Fail	275 lbs., 9-in. opening. Metal tore at end of crush pattern. 3-in. split - bottom.	
*158	H	37A	178.131	22	55	Open	Diagonal	4 FT	Fail	480 lbs. lever lock. New cover brought by manufacturer. Leak at end of crush, leak at closure.	38

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TABLE 4. TABLE OF RESULTS (Con't)

<u>Exhibit</u>	<u>Company</u>	<u>DOT Spec- ification</u>	<u>CFR Section Title 49</u>	<u>Gauge</u>	<u>Size</u>	<u>Type Closure</u>	<u>Test</u>	<u>Test Re- quirement</u>	<u>Re- sult</u>	<u>Remarks</u>	<u>Figure</u>
*159	H	37A	178.131	22	55	Opened	Horizontal	4 FT	Pass	480 lbs. Lever lock. No leaks.	
*160	G	37A	178.131	26	55	Opened	Diagonal	4 FT	Fail	150 lbs. torque 200 in.lbs. Leak at ring closure. Bib folded causing leak.	39
*161	G	37A	178.131	26	55	Opened	Diagonal	4 FT	Pass	150 lbs. torque 200 in.lbs.	
*162	G	37A	178.131	26	55	Opened	Diagonal	4 FT	Pass	150 lbs. torque 200 in.lbs. Slow leak at second attitude upon rolling.	
*163	G	37A	178.131	26	55	Opened	Horizontal	4 FT	Fail	150 lbs. torque 200 in.lbs. Closure placed at end of crush. Leak at impact at closure. Leak continued upon rolling.	40
*164	G	37A	178.131	26	55	Opened	Horizontal	4 FT	Pass	150 lbs. torque 200 in.-lbs. Slow leak at second attitude upon rolling.	
*165	H	37A	178.131	22	55	Opened	Horizontal	4 FT	Pass	480 lbs. Lever lock. No leaks.	
*166	H	37A	178.131	22	55	Opened	Horizontal	4 FT	Pass	480 lbs. Lever lock. Slight puff upon rolling.	
*167	H	37B	178.132	22	55	Opened	Diagonal	4 FT	Pass	650 lbs. 9-in. opening. No leaks.	

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TABLE 4. TABLE OF RESULTS (Con't)

<u>Exhibit</u>	<u>Company</u>	<u>DOT Spec- ification</u>	<u>CFR Section Title 49</u>	<u>Gauge</u>	<u>Size</u>	<u>Type Closure</u>	<u>Test</u>	<u>Test Re- quirement</u>	<u>Re- sult</u>	<u>Remarks</u>	<u>Figure</u>
1	A	17E	178.116	24	5	Closed	Pneumatic	5 PSIG	Pass	Leak at flexible spout - flex- ible spout recripped, retested. No leaks.	
2	A	17E	178.116	24	5	Closed	Hydro- static	15 PSIG	Void	Unable to torque cap.	
3	A	17E	178.116	24	5	Closed	Diagonal	4 FT	Pass	Torque - 75 in.lb.	
4	A	17E	178.116	24	5	Closed	Horizontal	4 FT	Pass	Torque - 35 in.lb.	
5	B	37C	178.135	28/26	5	Opened	Diagonal	32"	Fail	Diagonal drop 32 inches. Leak at impact area.	21
6	B	37C	178.135	28/26	5	Opened	Diagonal	32"	Fail	Diagonal drop 32 inches. Leak at impact area.	
7	B	37C	178.135	28/26	5	Opened	Hydro- static	15 PSIG	Fail	Leak at 4 psi. Crowning at head excessive.	10
8	B	37C	178.135	28/26	5	Opened	Diagonal	32"	Fail	Leak at lugs where pail creased - midway up pail - leak at all positions.	22
9	B	37C	178.135	28/26	5	Opened	Pneumatic	5 PSIG	Fail	Leak at 4 psi. Excessive crowning at top.	
10	B	37C	178.135	28/26	5	Opened	Pneumatic	5 PSIG	Fail	Leak at 3-1/2 psi. Crowning top and bottom.	

TABLE 4. TABLE OF RESULTS (Con't)

<u>Exhibit</u>	<u>Company</u>	<u>DOT Specification</u>	<u>CFR Section Title 49</u>	<u>Gauge</u>	<u>Size</u>	<u>Type Closure</u>	<u>Test</u>	<u>Test Requirement</u>	<u>Results</u>	<u>Remarks</u>	<u>Figure</u>
11	B	37C	178.135	28/26	5	Opened	Horizontal	32"	Fail	Leak at impact area at lugs. Continued to leak at all positions.	
12	D	17E	178.116	24	5	Closed	Hydro-static	15 PSIG	Pass	Slight crowning top and bottom.	
13	D	17E	178.116	24	5	Closed	Hydro-static	15 PSIG	Pass	Moderate crowning, radial lines top and bottom.	
14	D	17E	178.116	24	5	Closed	Hydro-static	15 PSIG	Pass	Slight crowning, top and bottom.	
15	D	17E	178.116	24	5	Closed	Diagonal	4 FT	Pass		
16	D	17E	178.116	24	5	Closed	Diagonal	4 FT	Pass		
17	D	17E	178.116	24	5	Closed	Diagonal	4 FT	Pass		
18	D	17E	178.116	24	5	Closed	Pneumatic	5 PSIG	Pass		
19	D	17E	178.116	24	5	Closed	Pneumatic	5 PSIG	Pass		
20	D	17E	178.116	24	5	Closed	Pneumatic	5 PSIG	Pass		
21	D	17E	178.116	24	5	Closed	Horizontal	4 FT	Pass	No leak.	
22	D	17E	178.116	24	5	Closed	Horizontal	4 FT	Pass		

TABLE 4. TABLE OF RESULTS (Con't)

Exhibit	Company	DOT Specification	CFR Section Title 49	Gauge	Size	Type Closure	Test	Test Requirement	Result	Remarks
23	D	17E	178.116	24	5	Closed	Horizontal	4 FT	Pass	
24	E	17E	178.116	24	5	Closed	Hydrostatic	15 PSIG	Pass	
25	E	17E	178.116	24	5	Closed	Diagonal	4 FT	Void	Flexible spout completely left pail causing immediate emptying of pail. Improper crimp
26	E	17E	178.116	24	5	Closed	Pneumatic	5 PSIG	Pass	
27	E	17E	178.116	24	5	Closed	Horizontal	4 FT	Pass	Slight puff at impact.
28	D	37B	178.132	28	5	Closed	Hydrostatic	7 PSIG	Pass	Moderate crowning top and bottom.
29	D	37B	178.132	28	5	Closed	Hydrostatic	7 PSIG	Fail	Leak at 1.5 PSIG at flexible spout.
30	D	37B	178.132	28	5	Closed	Hydrostatic	7 PSIG	Pass	Moderate crowning top and bottom.
31	D	37B	178.132	28	5	Closed	Diagonal	4 FT	Pass	
32	D	37B	178.132	28	5	Closed	Diagonal	4 FT	Pass	
33	D	37B	178.132	28	5	Closed	Pneumatic	5 PSIG	Pass	Very slight crowning radial lines on top and bottom.
34	D	37B	178.132	28	5	Closed	Pneumatic	5 PSIG	Pass	Very slight crowning radial lines on top and bottom.

Figure 10-10-10

TABLE 4. TABLE OF RESULTS (Con't)

Exhibit	Company	DOT Spec- ification	CFR Section Title 49	Gauge	Size	Type Closure	Test	Test Re- quirement	Re- sult	Remarks	Figure
35	D	37B	178.132	28	5	Closed	Horizontal	4 FT	Pass		
36	C	17E	178.116	24	5	Closed	Hydro- static	15 PSIG	Fail	Leak at chime. Excessive crowning at top - 15 PSI	
37	C	17E	178.116	24	5	Closed	Diagonal	4 FT	Fail	Leak from under crimp of spout.	20
38	C	17E	178.116	24	5	Closed	Pneumatic	5 PSIG	Pass		
39	C	17E	178.116	24	5	Closed	Horizontal	4 FT	Pass		
40	J	37A	178.131	24	5	Opened	Diagonal	4 FT	Pass	Leak at second attitude.	
41	J	37A	178.131	24	5	Opened	Diagonal	4 FT	Fail	Leak at end of crush pattern.	
42	J	37A	178.131	24	5	Opened	Diagonal	42 IN	Pass	Diagonal drop at 42 inches. No leak.	
43	J	37A	178.131	26	5	Opened	Diagonal	42 IN	Fail	Puff at impact. Slow leak in impact. 42-inch drop.	24
44	J	37A	178.131	26	5	Opened	Diagonal	4 FT	Fail	Massive leak at end of crush pattern.	23
45	J	37A	178.131	26	5	Opened	Horizontal	42 IN	Fail	Severe leak.	
46	J	37A	178.131	26	5	Opened	Diagonal	36 IN	Fail	Slow leak.	25

TABLE 4. TABLE OF RESULTS (Con't)

Exhibit	Company	DOT Spec- ification	CFR Section Title 49	Gauge	Size	Type Closure	Test	Test Re- quirement	Re- sult	Remarks	Figures
47	J	37A	178.131	26	5	Opened	Diagonal	36 IN	Fail	Leak at end of crush.	26
48	J	37A	178.131	26	5	Opened	Hydro- static	7 PSIG	Fail	Massive leak between 5 and 6 PSIG at crimp joint seal.	11
49	J	37A	178.131	26	5	Opened	Pneumatic	5 PSIG	Fail	Leak at 3 PSIG at crimp in lid.	12
50	J	37A	178.131	24	5	Opened	Horizontal	42 IN	Fail	Leak at impact area.	35
51	J	37A	178.131	24	5	Opened	Hydro- static	7 PSIG	Pass	Very slight crowning top and bottom.	
52	J	37A	178.131	24	5	Opened	Pneumatic	5 PSIG	Pass		
53	J	17E	178.116	24	5	Closed	Hydro- static	15 PSIG	Pass	Crowning top and bottom.	
54	J	17E	178.116	24	5	Closed	Diagonal	4 FT	Pass		
55	J	17E	178.116	24	5	Closed	Pneumatic	5 PSIG	Fail	Leak at 4 PSIG at intersection of top chime and seam weld.	13
56	J	37C	178.135	28/26	5	Opened	Diagonal	28 IN	Pass	Puff at impact.	
57	J	37C	178.135	28/26	5	Opened	Diagonal	32 IN	Fail	Leak at impact.	
58	J	37C	178.135	28/26	5	Opened	Diagonal	28 IN	Pass		

TABLE 4. TABLE OF RESULTS (Con't)

Exhibit	Company	DOT Specification	CFR Section Title 49	Gauge	Size	Type Closure	Test	Test Requirement	Result	Remarks	Figure
59	J	37C	178.135	28/26	5	Opened	Diagonal	28 IN	Pass		
60	J	37C	178.135	28/26	5	Opened	Horizontal	28 IN	Fail	Leak in impact area.	34
61	J	37C	178.135	28/26	5	Opened	Horizontal	28 IN	Fail	Leak in impact area.	33
62	J	37C	178.135	28/26	5	Opened	Horizontal	28 IN	Void	Leak at handle anchor upon filling.	
63	C	37C	178.135	28/26	5	Opened	Diagonal	28 IN	Pass	Puff at impact.	
64	C	37C	178.135	28/26	5	Opened	Diagonal	28 IN	Pass	Puff at impact.	
65	C	37C	178.135	28/26	5	Opened	Horizontal	24 IN	Pass	Puff at impact.	
66	C	37C	178.135	28/26	5	Opened	Horizontal	24 IN	Fail	Leak in impact area.	32
67	C	37C	178.135	28/26	5	Opened	Diagonal	28 IN	Fail	Leak at impact.	
68	E	37C	178.135	28/26	5	Opened	Diagonal	28 IN	Pass	Puff at impact.	
69	E	37C	178.135	28/26	5	Opened	Diagonal	28 IN	Pass	Puff at impact. Leak at second attitude.	
70	E	37C	178.135	28/26	5	Opened	Horizontal	24 IN	Pass	Puff at impact.	

TABLE 4. TABLE OF RESULTS (Con't)

<u>Exhibit</u>	<u>Company</u>	<u>DOT Spec- ification</u>	<u>CFR Section Title 49</u>	<u>Gauge</u>	<u>Size</u>	<u>Type Closure</u>	<u>Test</u>	<u>Test Re- quirement</u>	<u>Re- sult</u>	<u>Remarks</u>	<u>Figure</u>
71	E	37C	178.135	28/26	5	Opened	Horizontal	24 IN	Pass	Puff at impact.	
72	E	37C	178.135	28/26	5	Opened	Horizontal	24 IN	Pass	Puff at impact.	
73	L	37C	178.135	28/26	5	Opened	Hydro- static	5 PSIG	Fail	Leak from under crimp at 5 PSIG.	
74	L	37C	178.135	28/26	5	Opened	Diagonal	28 IN	Pass	Slight puff.	
75	L	37C	178.135	28/26	5	Opened	Diagonal	28 IN	Pass		
76	L	37C	178.135	28/26	5	Opened	Pneumatic	5 PSIG	Fail	Leak from under crimp at 5 PSIG	
77	L	37C	178.135	28/26	5	Opened	Horizontal	24 IN	Pass		
78	L	37C	178.135	28/26	5	Opened	Horizontal	24 IN	Pass		
79	L	37B	178.132	28	5	Closed	Hydro- static	7 PSIG	Pass	Slight crowning top and bottom.	
80	L	37B	178.132	28	5	Closed	Hydro- static	7 PSIG	Pass	Slight crowning top and bottom.	
81	L	37B	178.132	28	5	Closed	Diagonal	4 FT	Pass	Slight crowning top and bottom.	
82	L	37B	178.132	28	5	Closed	Diagonal	4 FT	Pass		
83	L	37B	178.132	28	5	Closed	Pneumatic	5 PSIG	Pass	Slight crowning top and bottom.	

TABLE 4. TABLE OF RESULTS (Con't)

Exhibit	Company	DOT Specification	CFR Section Title 49	Gauge	Size	Type Closure	Test	Test Requirement	Result	Remarks	Figure
84	L	37B	178.132	28	5	Closed	Horizontal	4 FT	Pass		
85	L	17E	178.116	24	5	Closed	Hydro-static	15 PSIG	Pass	Crowning and radial lines top and bottom.	
86	L	17E	178.116	24	5	Closed	Hydro-static	15 PSIG	Pass	Crowning and radial lines top and bottom.	
87	L	17E	178.116	24	5	Closed	Diagonal	4 FT	Pass		
88	L	17E	178.116	24	5	Closed	Pneumatic	5 PSIG	Pass		
89	L	17E	178.116	24	5	Closed	Horizontal	4 FT	Pass		
*90	J	37A	178.131	26	5	Opened	Diagonal	4 FT	Fail	Leak at end of crush pattern.	42
*91	J	37A	178.131	26	5	Opened	Diagonal	4 FT	Fail	Leak at both ends of crush pattern.	43
*92	J	37A	178.131	26	5	Opened	Horizontal	4 FT	Pass		
*93	J	37A	178.131	24	5	Opened	Diagonal	4 FT	Pass		
*94	J	37A	178.131	24	5	Opened	Diagonal	4 FT	Pass		
*95	J	37A	178.131	24	5	Opened	Horizontal	4 FT	Pass	80 lbs.	
*96	C	37C	178.135	28/26	5	Opened	Diagonal	4 FT	Pass	80 lbs.	

*Powder

TABLE 4. TABLE OF RESULTS (Con't)

Exhibit	Company	DOT Specification	CFR Section Title 49	Gauge	Size	Type Closure	Test	Test Requirement	Re- sult	Remarks	Figure
*97	C	37C	178.135	28/26	5	Opened	Diagonal	4 FT	Pass	80 lbs. Slight leak end of crush - second attitude.	
*98	C	37C	178.135	28/26	5	Opened	Horizontal	4 FT	Pass	80 lbs.	
*99	C	37C	178.135	28/26	5	Opened	Horizontal	4 FT	Pass	80 lbs.	
*100	B	37C	178.135	28/26	5	Opened	Diagonal	4 FT	Pass	Puff at impact. Leak end of crush. Second attitude. 80 lbs.	
*101	B	37C	178.135	28/26	5	Opened	Diagonal	4 FT	Pass	Puff at impact. Leak end of crush. Second attitude. 80 lbs.	
*102	B	37C	178.135	28/26	5	Opened	Horizontal	4 FT	Pass	80 lbs.	
*103	J	37C	178.135	28/26	5	Opened	Diagonal	4 FT	Fail	Puff at impact. Leak ends of crush. 80 lbs.	44
*104	J	37C	178.135	28/26	5	Opened	Horizontal	4 FT	Pass	80 lbs.	
*105	E	37C	178.135	28/26	5	Opened	Diagonal	4 FT	Fail	Puff at impact. Leak ends of crush. 80 lbs.	45
*106	E	37C	178.135	28/26	5	Opened	Horizontal	4 FT	Pass	80 lbs.	
*107	D	37B	178.132	28	5	Closed	Diagonal	4 FT	Pass	60 lbs.	
*108	D	37B	178.132	28	5	Closed	Diagonal	4 FT	Pass	No Kieke flexible spout.	
*109	D	37B	178.132	28	5	Closed	Horizontal	4 FT	Pass	60 lbs.	

*Powder

TABLE 4. TABLE OF RESULTS (Con't)

Exhibit	Company	DOT Spec- ification	CFR Section Title 49	Gauge	Size	Type Closure	Test	Test Re- quirement	Re- sult	Remarks	Figure
*110	D	37B	178.132	28	5	Closed	Horizontal	4 FT	Pass	60 lbs.	
*111	L	37B	178.132	28	5	Closed	Diagonal	4 FT	Pass	60 lbs.	
*112	L	37B	178.132	28	5	Closed	Diagonal	4 FT	Pass	60 lbs.	
*113	L	37B	178.132	28	5	Closed	Horizontal	4 FT	Pass	60 lbs.	
*114	L	37B	178.132	28	5	Closed	Horizontal	4 FT	Pass	No Rieke flexible spout. 60 lbs.	
*115	L	37C	178.135	28/26	5	Opened	Diagonal	4 FT	Pass	Puff both ends of crush. Leak at second attitude. 80 lbs.	
*116	L	37C	178.135	28/26	5	Opened	Diagonal	4 FT	Fail	Puff both ends of crush. Leak both ends of crush. 80 lbs.	46
*117	L	37C	178.135	28/26	5	Opened	Horizontal	4 FT	Pass	80 lbs.	
*118	L	37C	178.135	28/26	5	Opened	Horizontal	4 FT	Pass	80 lbs.	

*Powder

TABLE 5. RESUME OF RESULTS FOR POWDER (DRY) CONTENTS

DOT Specification	Capacity Gallons	Content Weight	Number Tested	Closure	Results			Failures		
					Pass	Fail	Void	Gauge	Diagonal	Horizontal
37A	55	480	6	Lever Lock	3	3	0	22	3	0
37A	55	350	5	Lap Lock	5	-	0	24	0	0
37A	55	150	5	Standard Ring	3	2	0	26	1	1
37B	55	650	1	9" Open	1	0	1	22	0	0
37B	42	450	5	9" Open	5	-	0	24	0	0
37B	55	275	4	9" Open	2	2	0	26	1	1
TOTAL			26		19	7	1		5	2
PERCENTAGE					73.07	26.92			71.42	28.57
37A	5	80	3	Open Head	3	0	0	24	0	0
37A	5	60	3	Open Head	1	2	0	26	2	0
37B	5	60	6	Closed Head	6	0	2	28	0	0
37C	5	80	4	Open Head w/Rieke	3	1	0	28/26	1	0
37C	5	80	11	Open Head	9	2	0	28/26	2	0
TOTAL			27		22	5	2		5	0
PERCENTAGE					81.48	18.51			18.51	0
GRAND TOTAL			53		41	12			10	2
PERCENTAGE					77.35	22.64			83.33	16.66

TABLE 6. RESUME OF RESULTS FOR AIR AND LIQUID CONTENTS

DOT Specification	<u>Received</u>		<u>Results</u>			<u>Failures</u>			
	<u>Quantity</u>	<u>Tested</u>	<u>Pass</u>	<u>Fail</u>	<u>Void</u>	<u>Gauge</u>	<u>Diagonal</u>	<u>Horizontal</u>	<u>Pneumatic</u> <u>Hydrostatic</u>
<u>55-Gallon Drums</u>									
17E	41	41	40	1	0	18	1	0	0 0
17C	22	22	19	3	0	16	1	1	- 1
17H	39	39	20	18	1	18/16	5	6	0 7
37D	8	8	8	0	0	-	-	-	- -
37A	15	1	-	1	-	-	1	0	0 0
5B	15	15	14	1	0	16	0	1	0 0
6J	5	4	3	1	0	18	1	0	0 0
5A	5	5	5	0	0	-	-	-	- -
5	5	5	4	1	0	14	0	0	0 1
TOTAL	165	139	113	26	1	-	9	8	0 9
PERCENTAGE	57.09	84.24	81.29	17.98	.71	-	34.61	30.76	0 34.61

TABLE 6. RESUME OF RESULTS FOR AIR AND LIQUID CONTENTS (Con't)

DOT Specification	<u>Received</u>		<u>Results</u>				<u>Failures</u>			
	<u>Quantity</u>	<u>Tested</u>	<u>Pass</u>	<u>Fail</u>	<u>Void</u>	<u>Gauge</u>	<u>Diagonal</u>	<u>Horizontal</u>	<u>Pneumatic</u>	<u>Hydrostatic</u>
<u>5-Gallon Pails</u>										
17E	32	32	27	3	2	24	1	0	1	1
37C	49	30	15	14	1	28/26	5	4	3	2
37B	22	14	13	1	0	28	0	0	0	1
37A	21	13	4	9	0	24/26	5	2	1	1
TOTAL	124	89	59	27	3	-	11	6	5	5
PERCENTAGE	42.90	71.77	66.29	30.33	3.37	-	33.33	22.22	18.51	25.92
GRAND TOTAL	289	228	172	52	4	-	20	14	5	14
PERCENTAGE	94.75	78.89	75.43	22.80	1.75	-	36.53	25.00	9.61	28.84

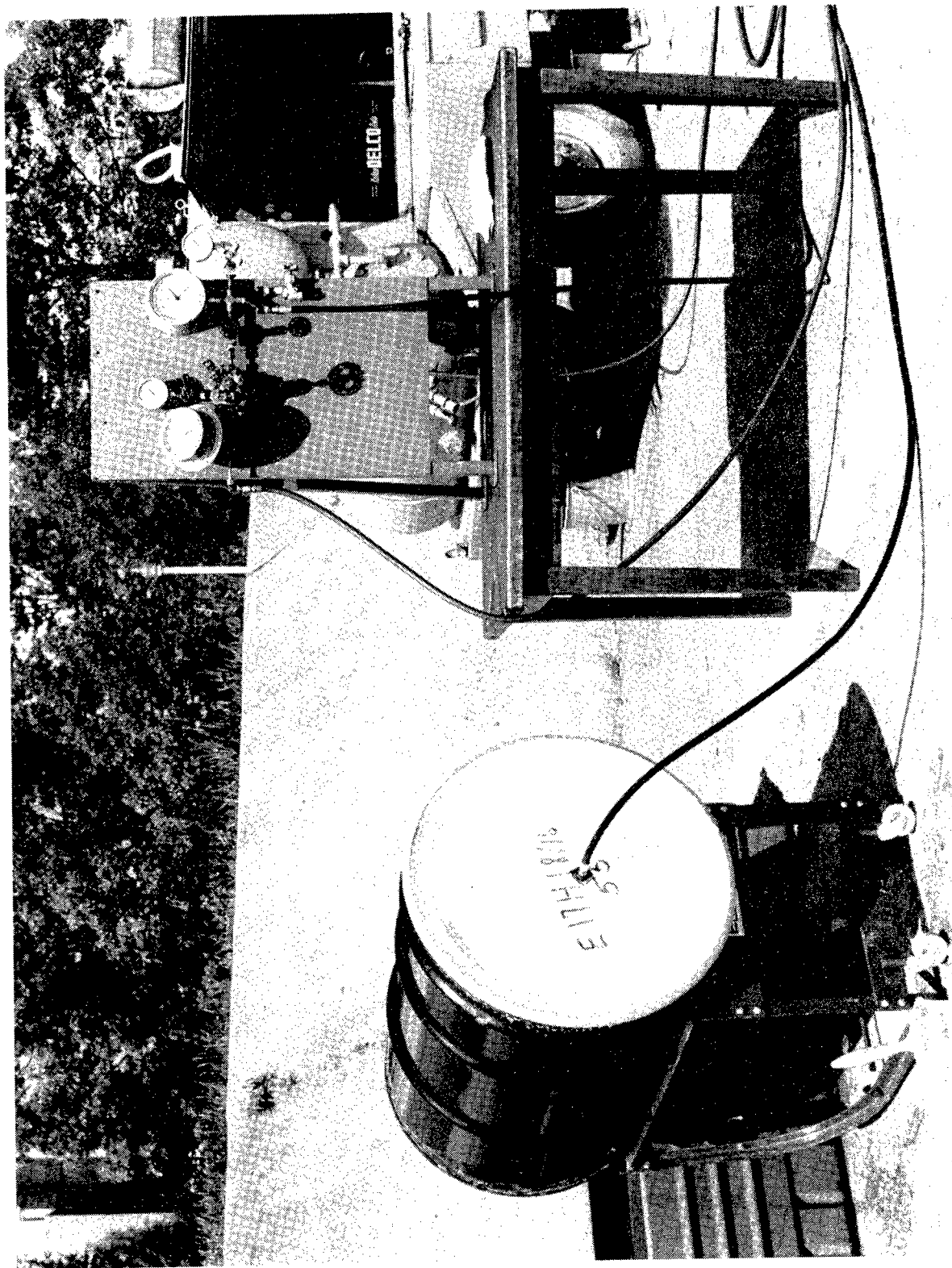


FIGURE 1 PRESSURE TEST

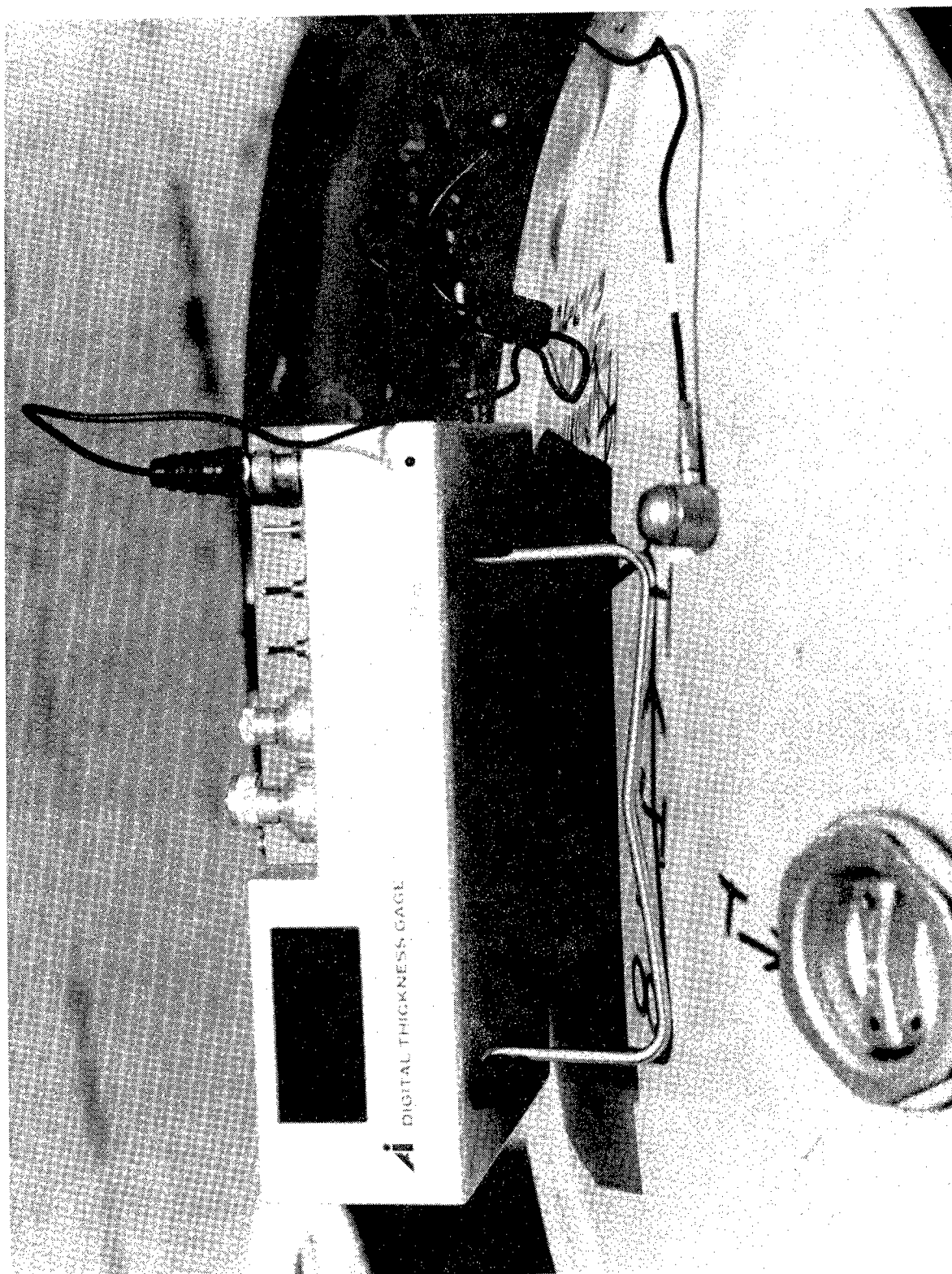


FIGURE 2 AUTOMATIC DIGITAL THICKNESS GAUGE



FIGURE 3

MEASURING GAUGE THICKNESS

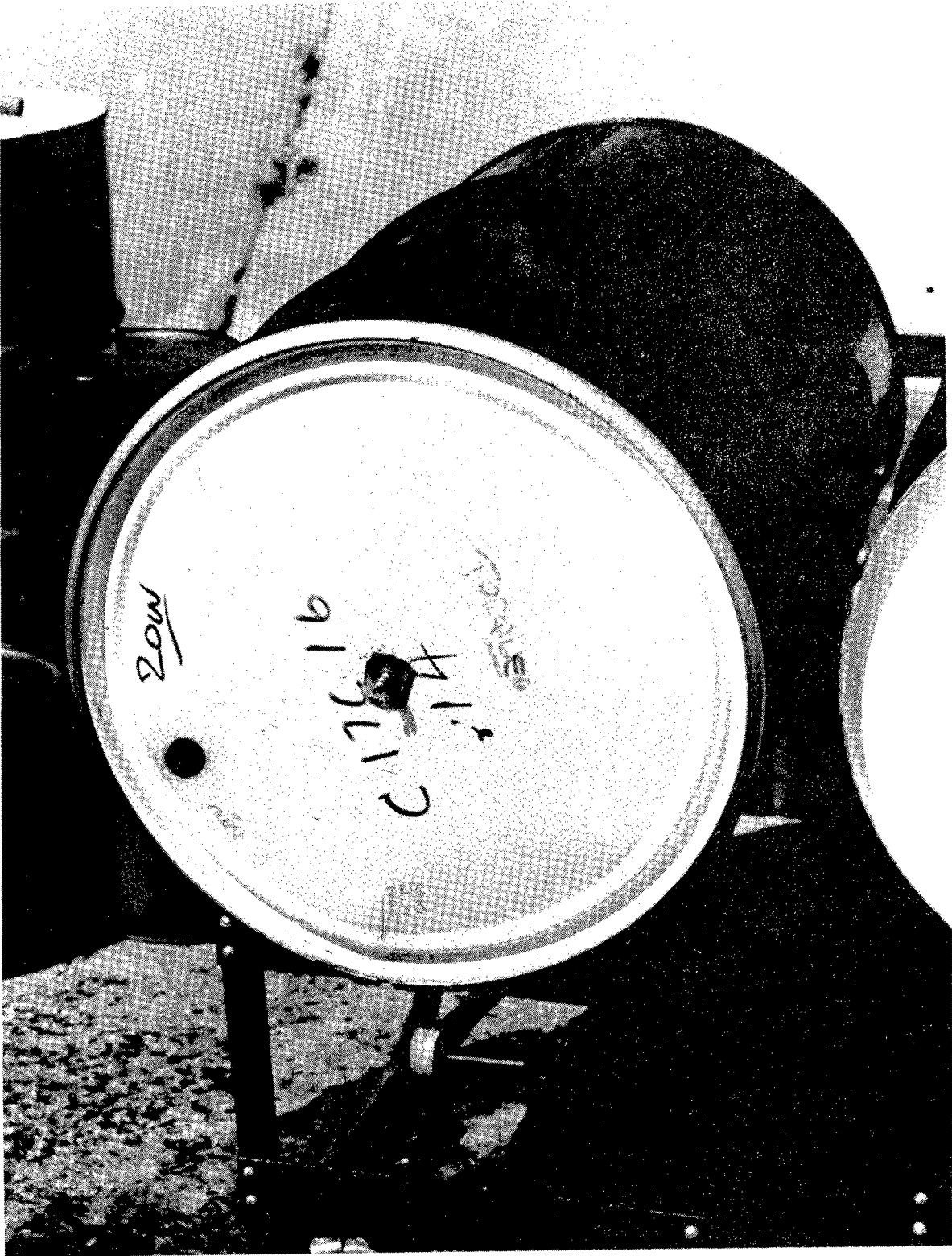


FIGURE 4

HYDROSTATIC PRESSURE TEST

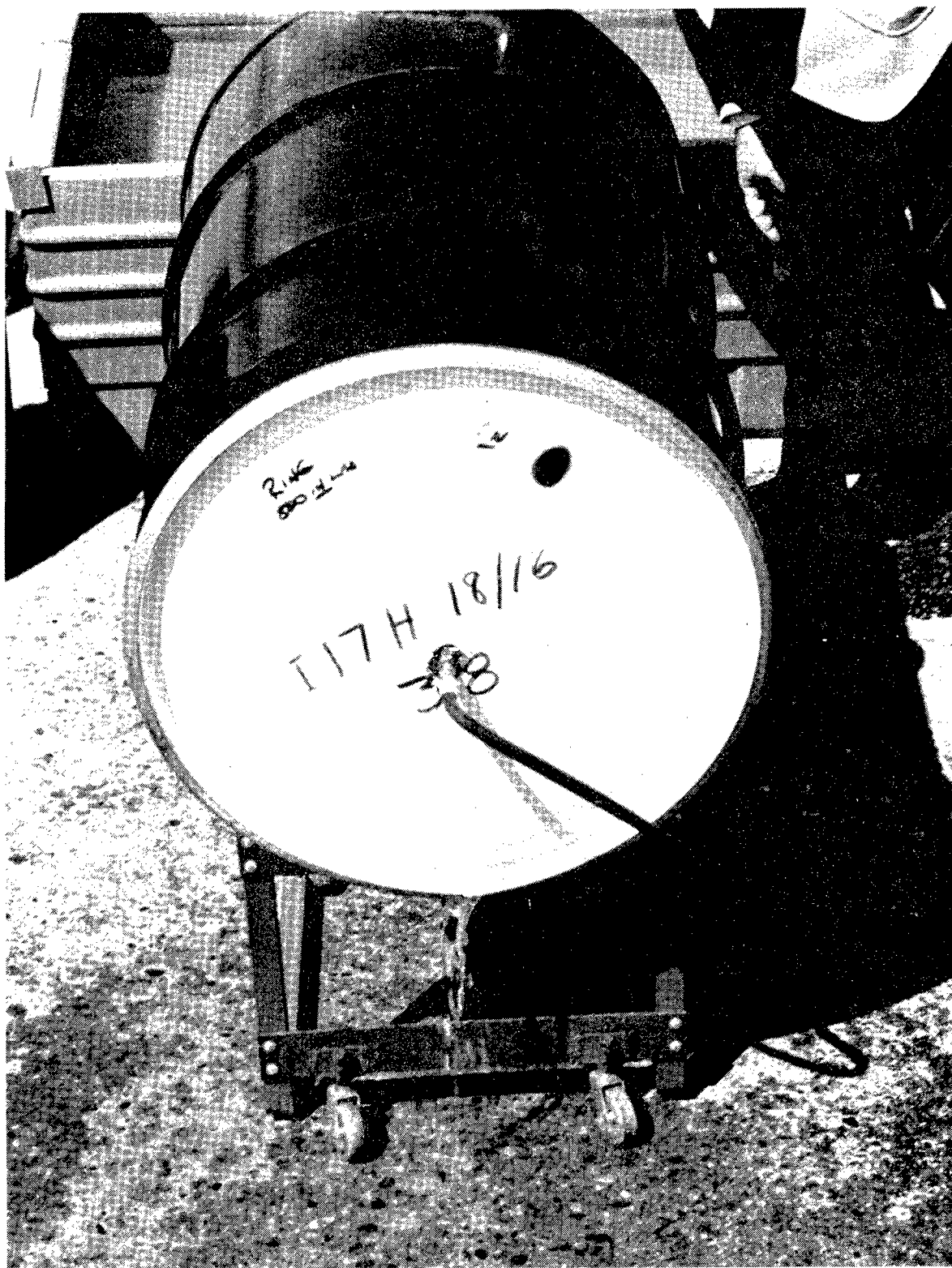
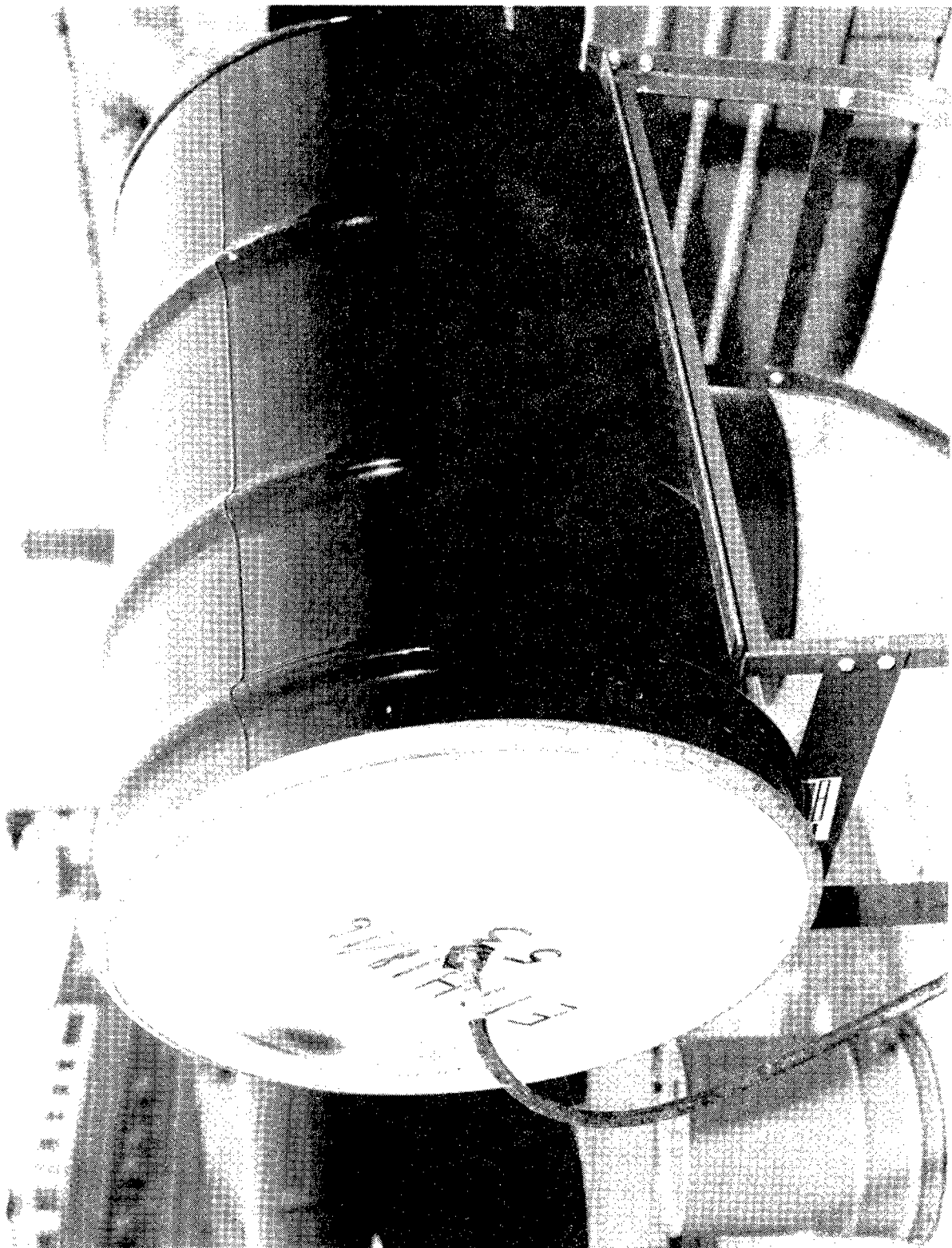


FIGURE 5

HYDROSTATIC PRESSURE TEST



HYDROSTATIC PRESSURE TEST

FIGURE 6

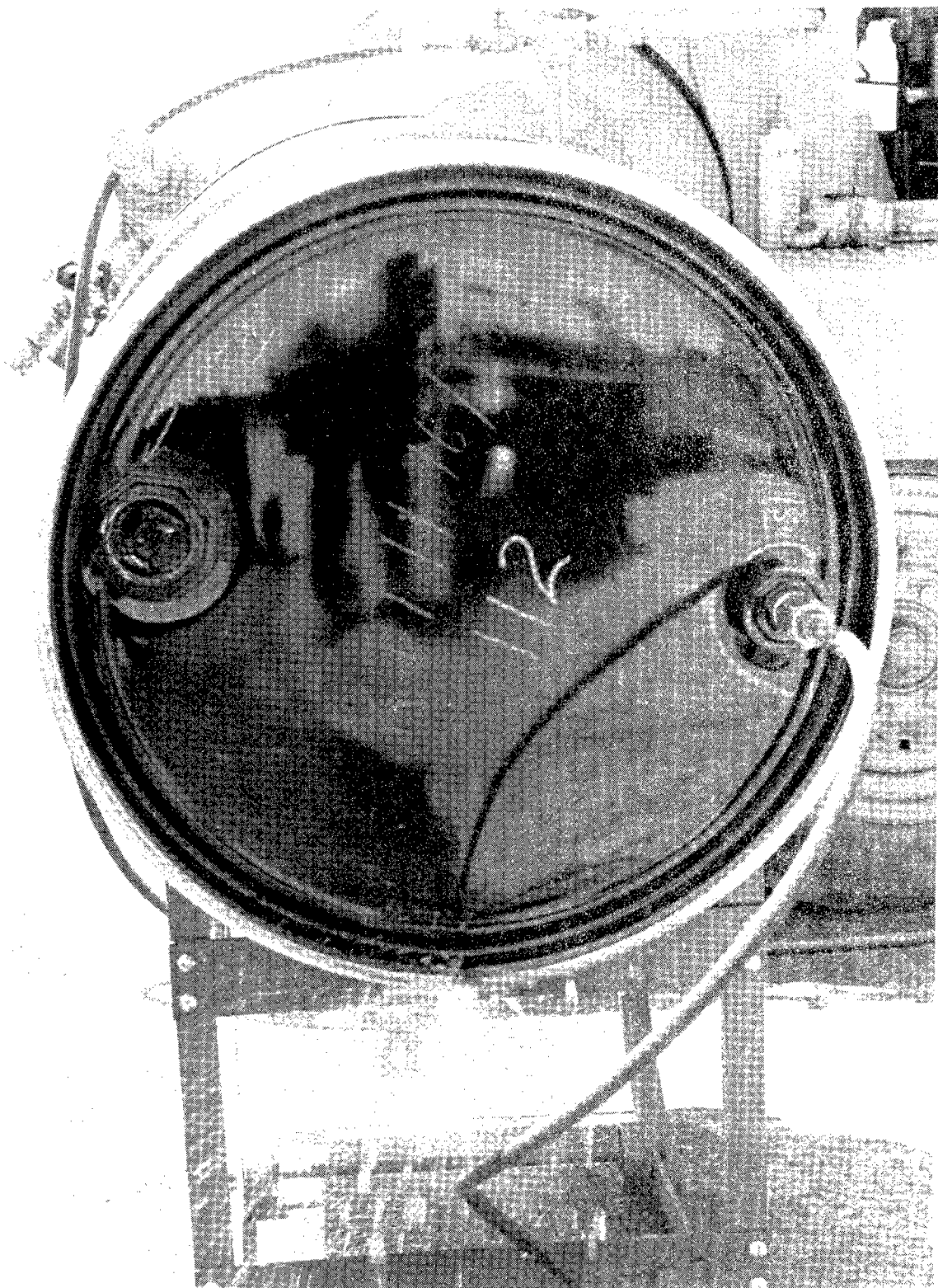


FIGURE 7

HYDROSTATIC PRESSURE TEST

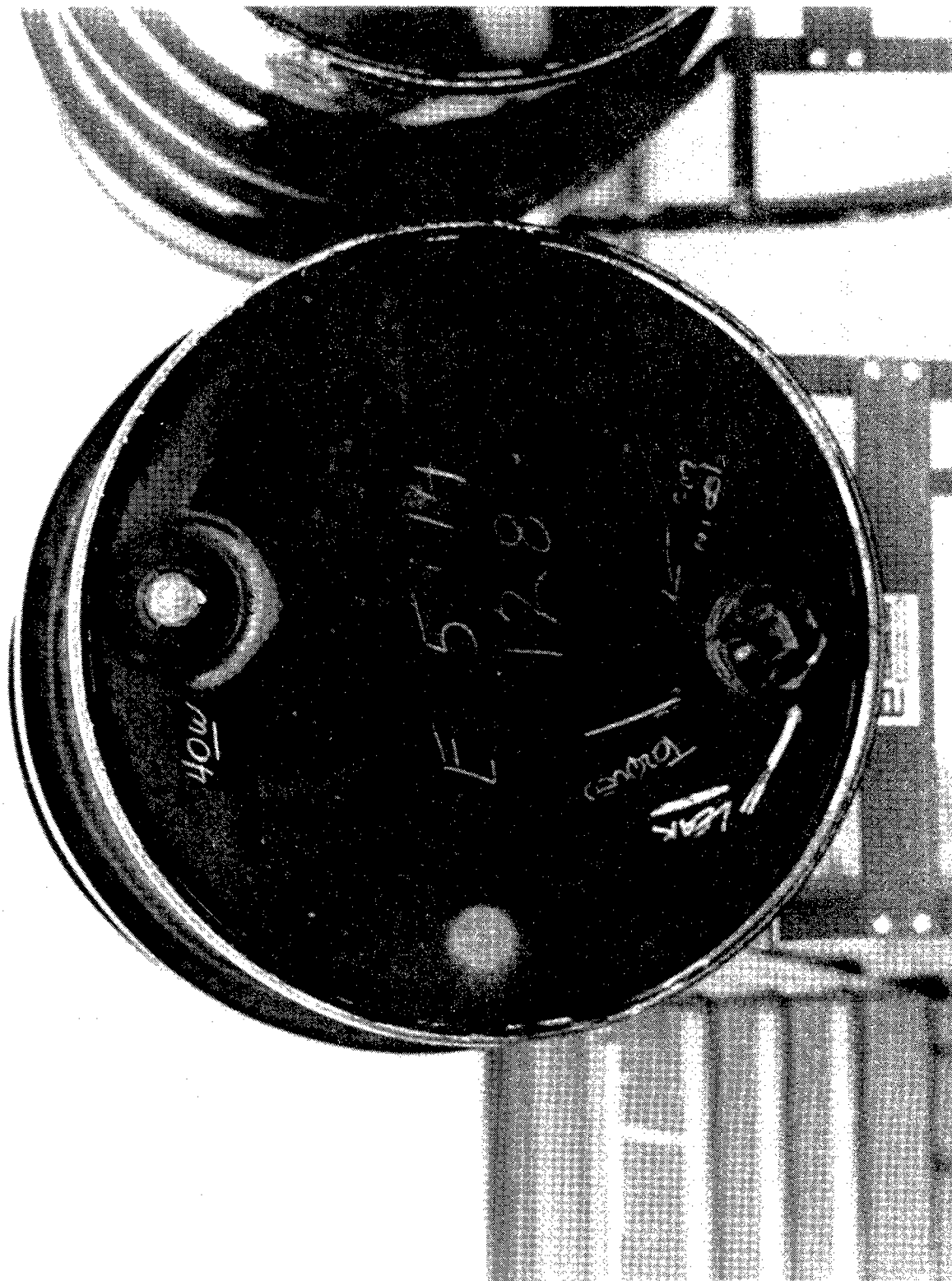


FIGURE 8 HYDROSTATIC PRESSURE TEST



FIGURE 9 HYDROSTATIC PRESSURE TEST



HYDROSTATIC PRESSURE TEST

FIGURE 10

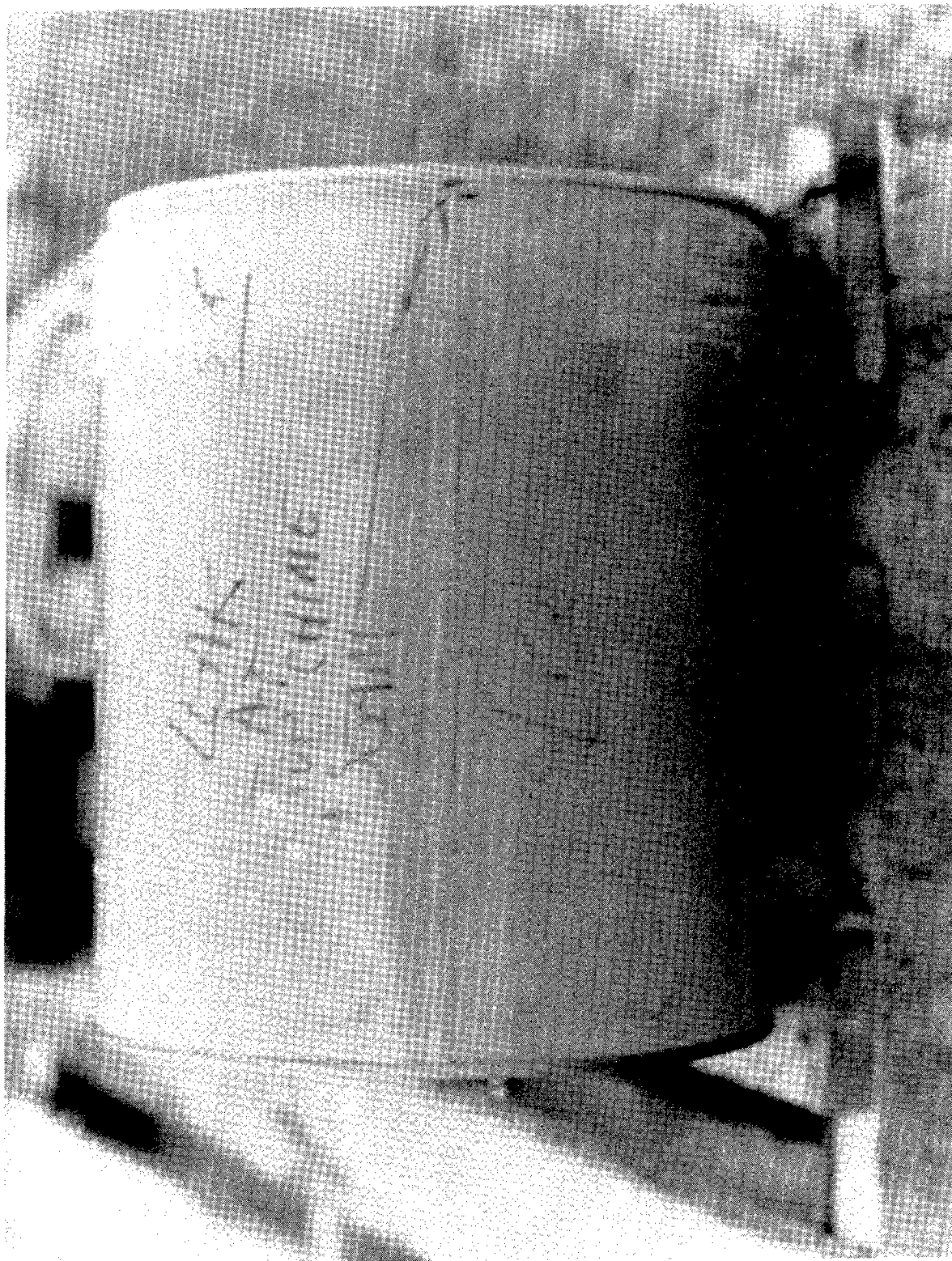


FIGURE 11 HYDROSTATIC PRESSURE TEST



PNEUMATIC LEAK TEST

FIGURE 12



PNEUMATIC LEAK TEST

FIGURE 13

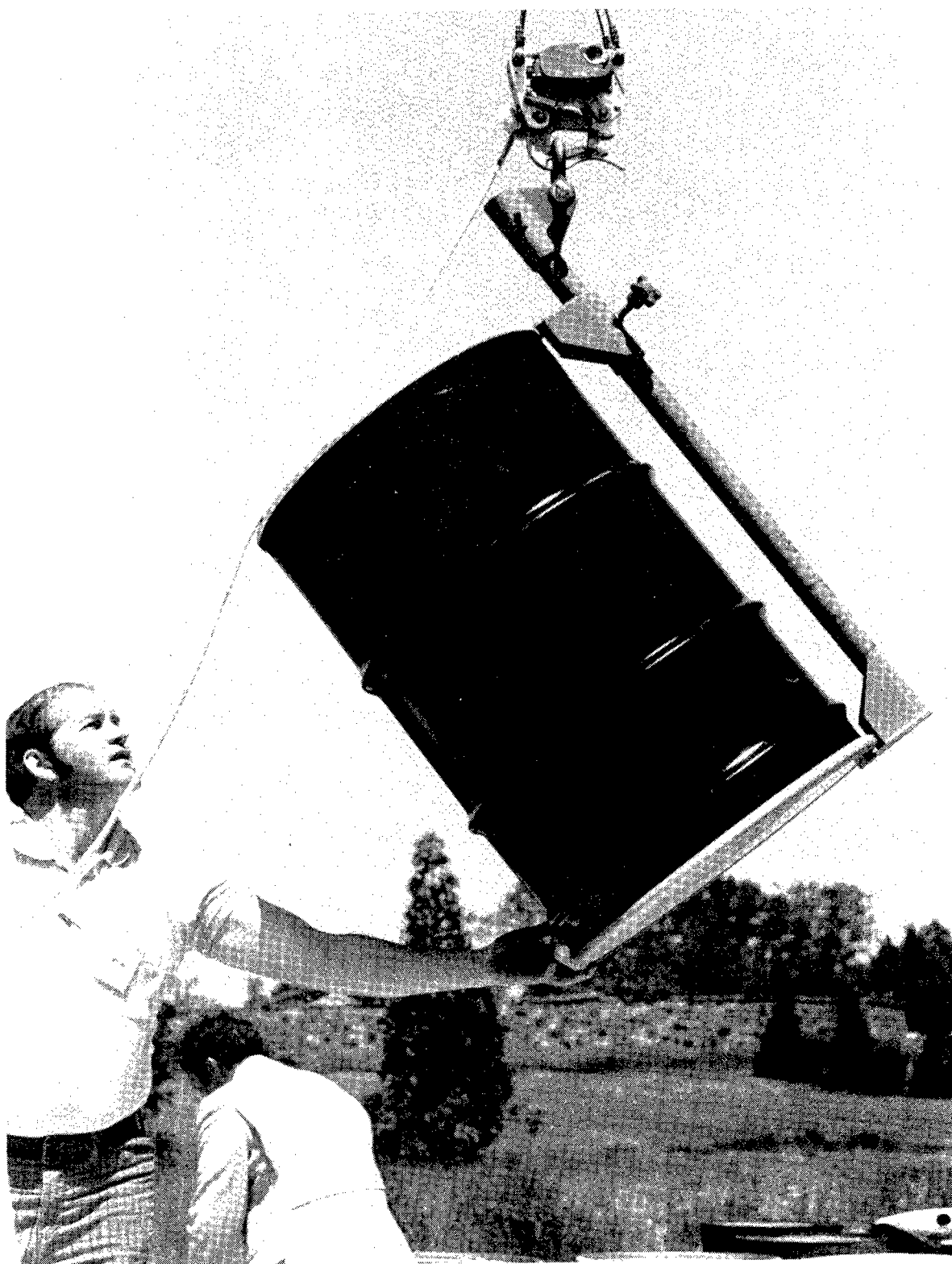


FIGURE 14

POSITION FOR DIAGONAL DROP



DIAGONAL DROP TEST

FIGURE 15

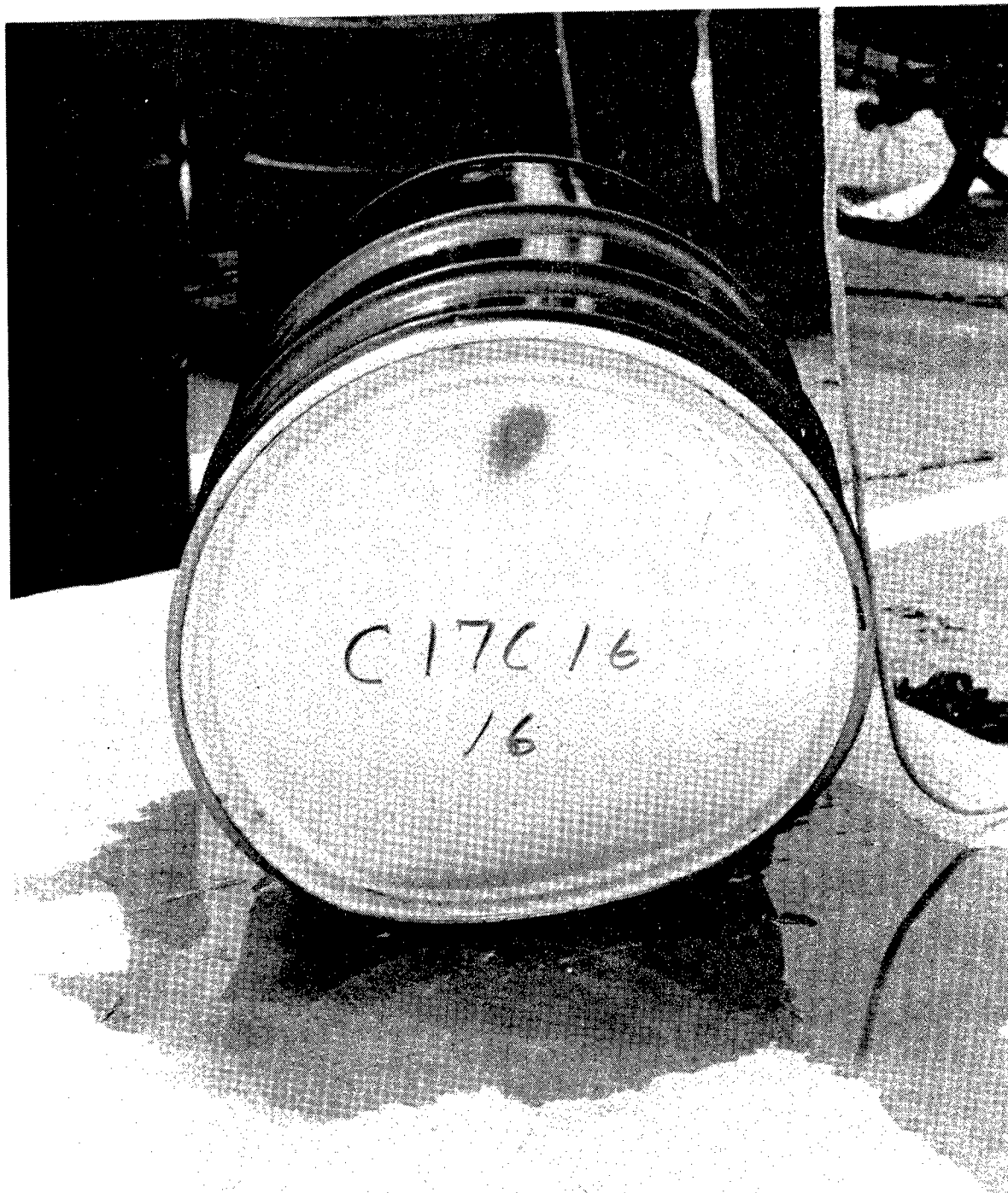


FIGURE 16

DIAGONAL DROP TEST

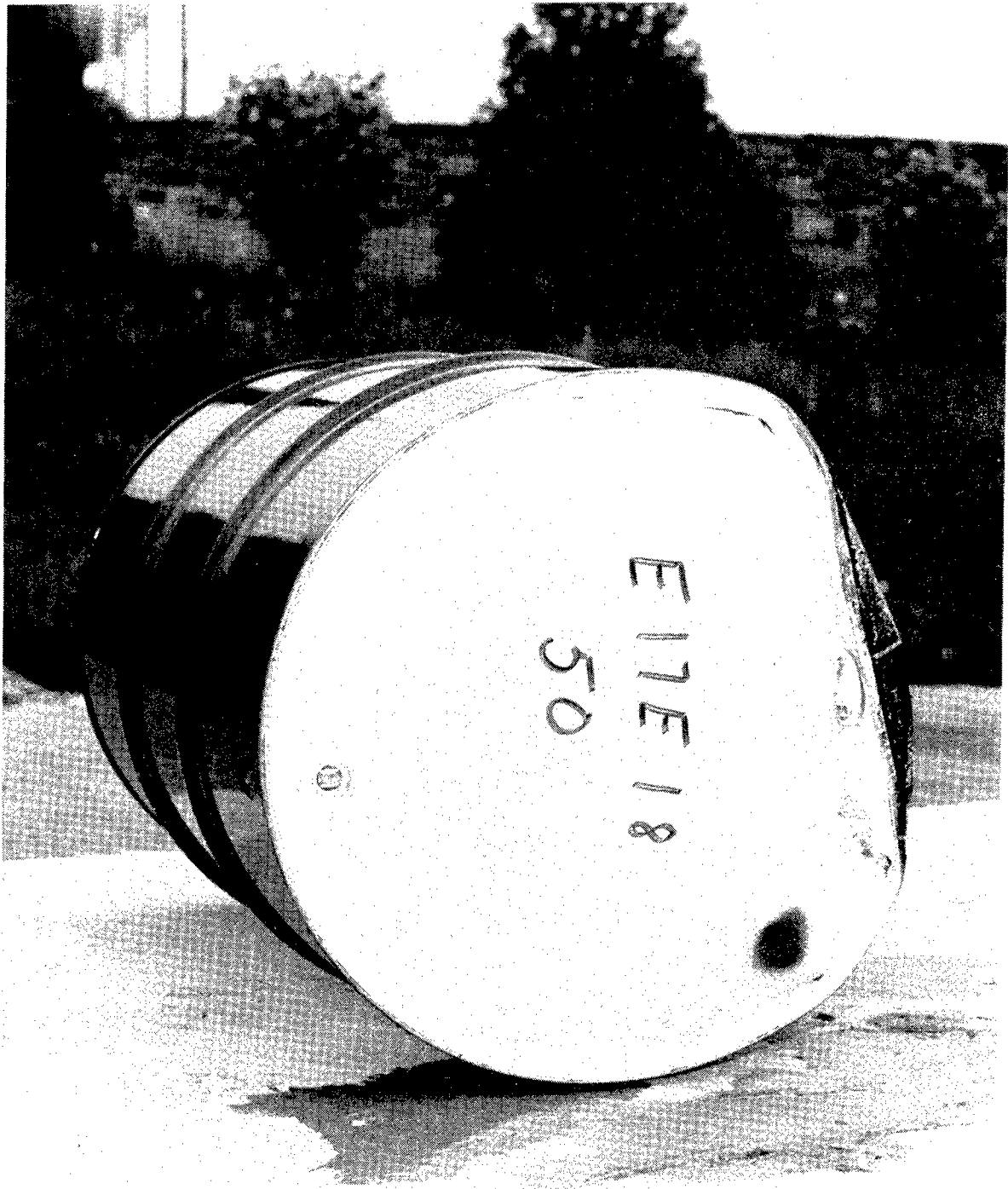


FIGURE 17

DIAGONAL DROP TEST



DIAGONAL DROP TEST

FIGURE 18

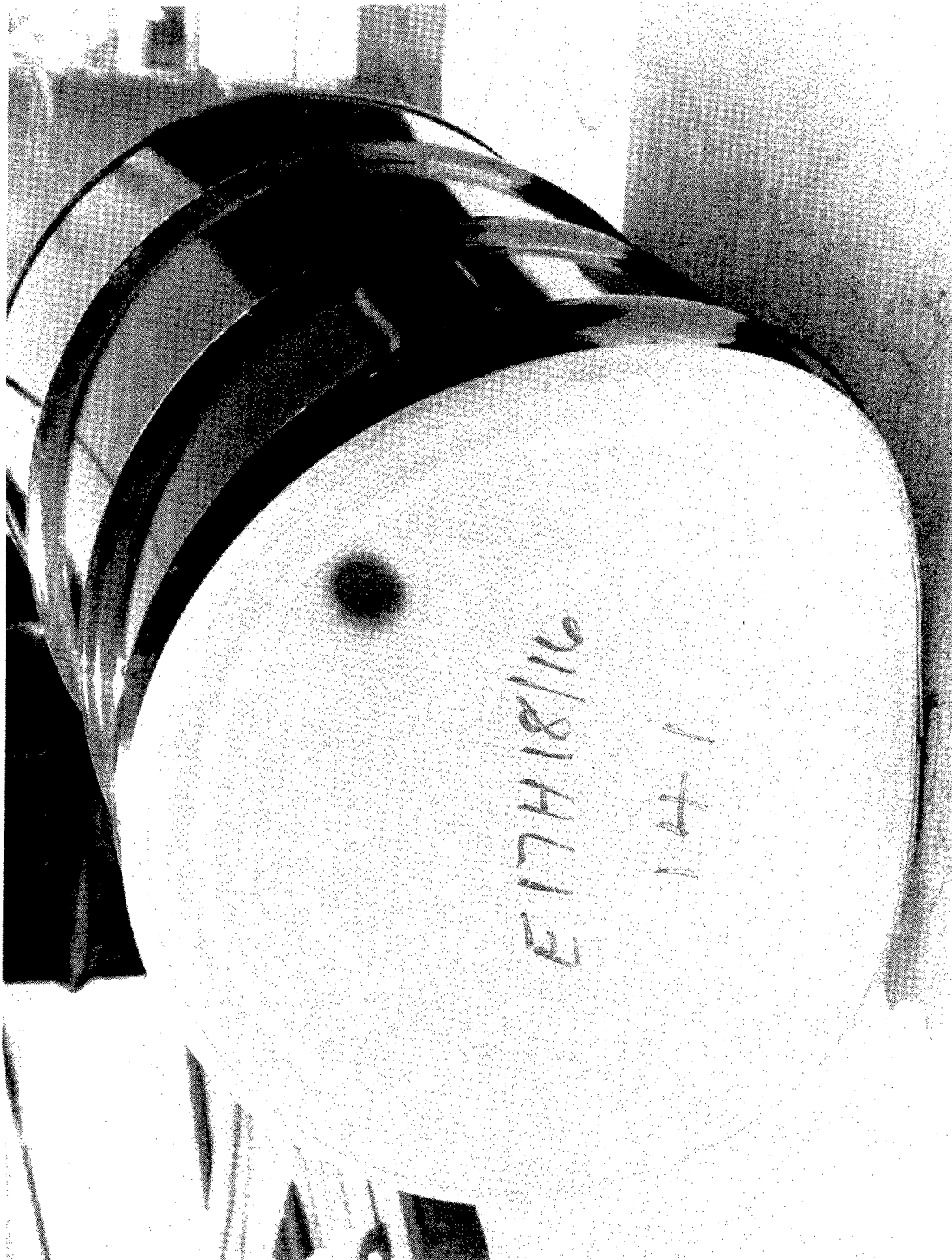
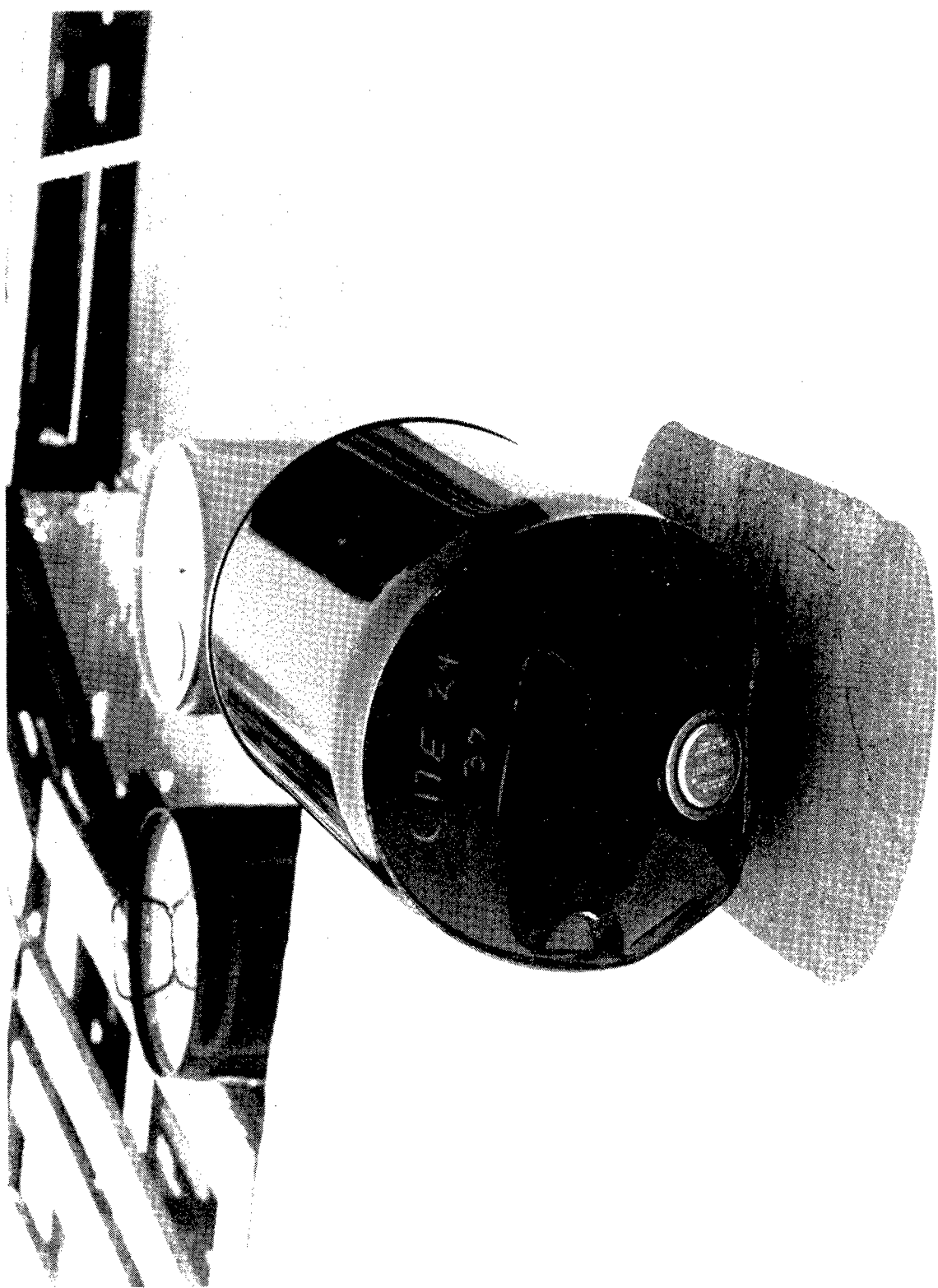


FIGURE 19 DIAGONAL DROP TEST



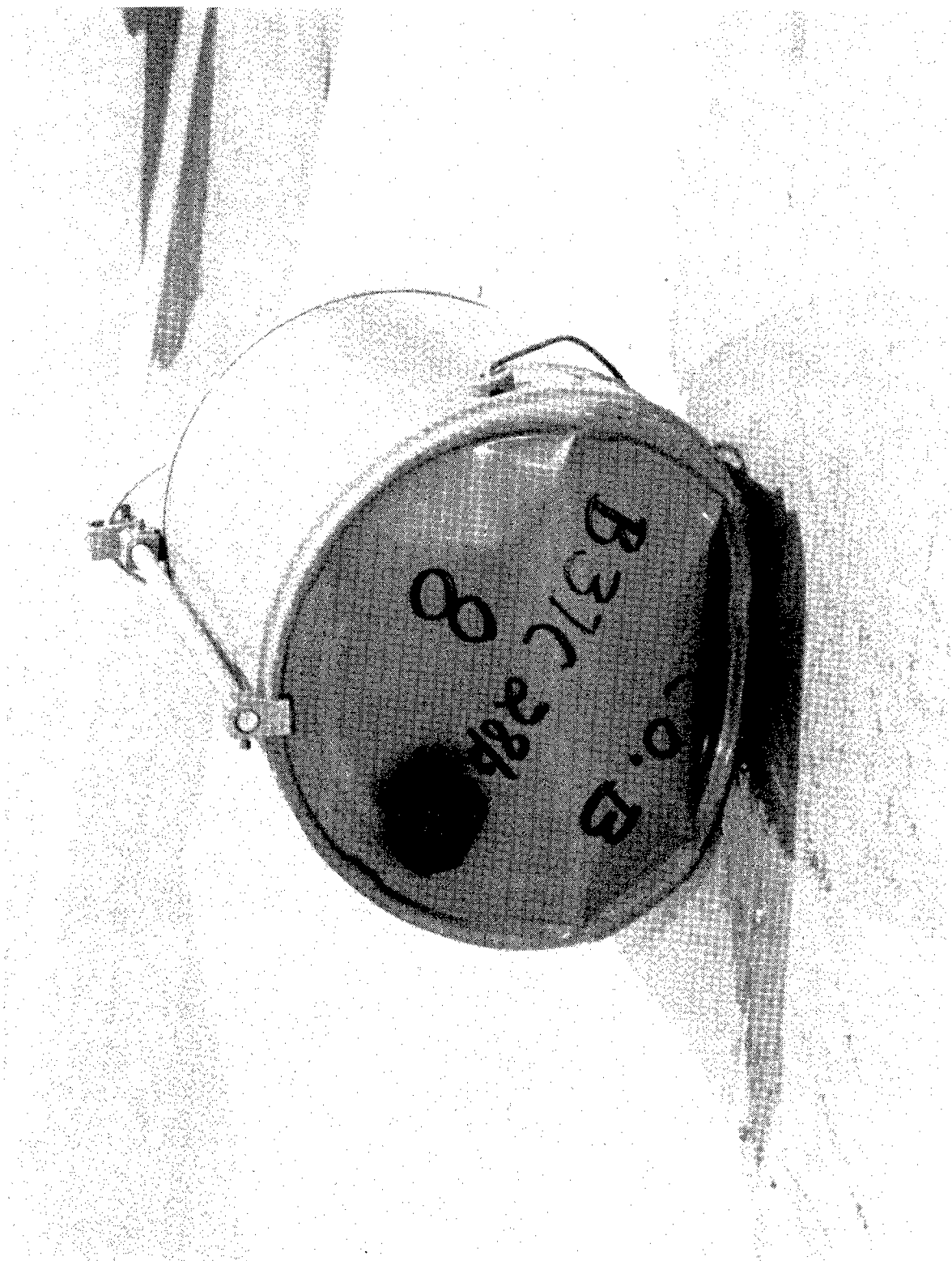
DIAGONAL DROP TEST

FIGURE 20



DIAGONAL DROP TEST

FIGURE 21



DIAGONAL DROP TEST

FIGURE 22

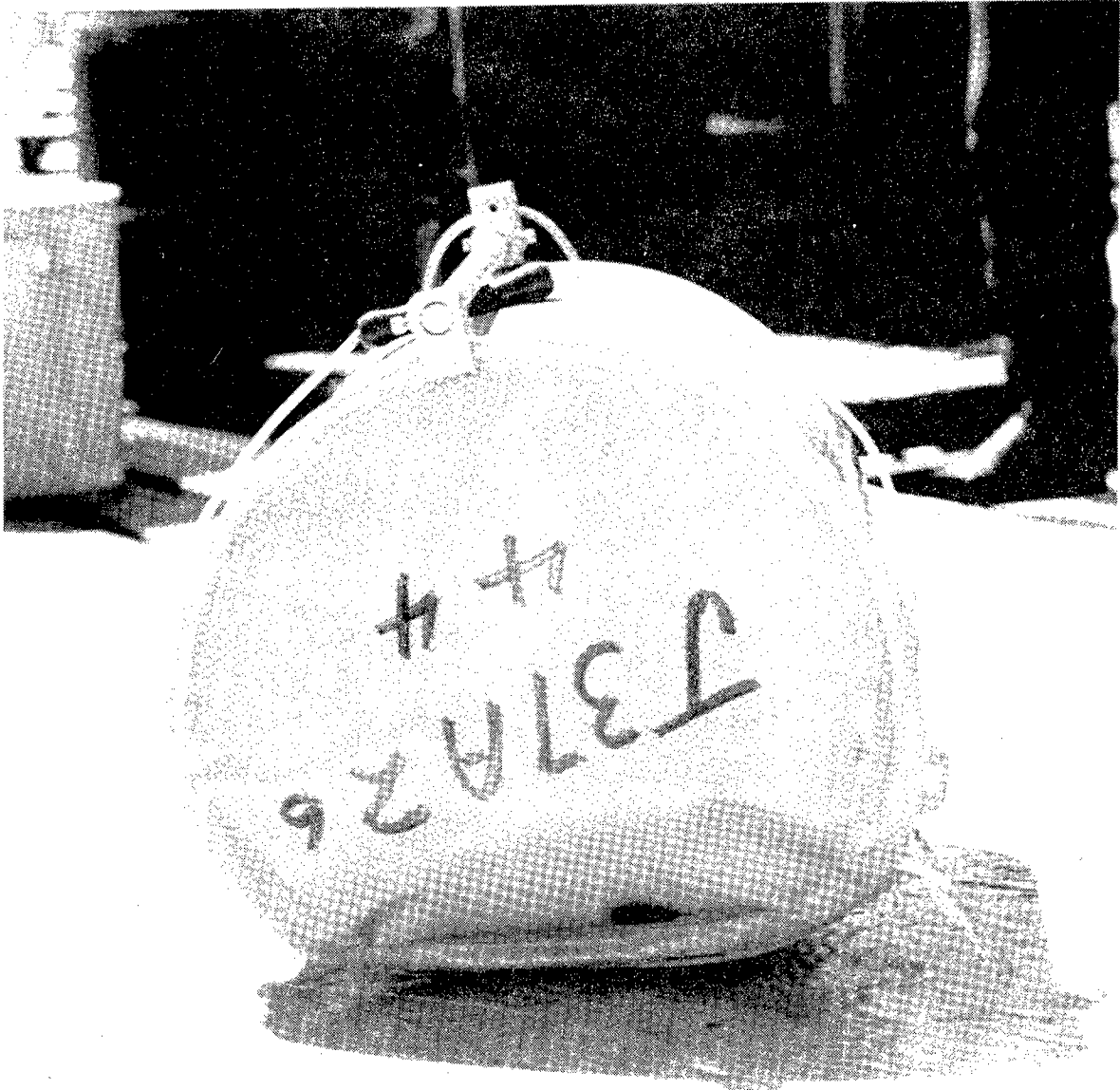


FIGURE 23

DIAGONAL DROP TEST

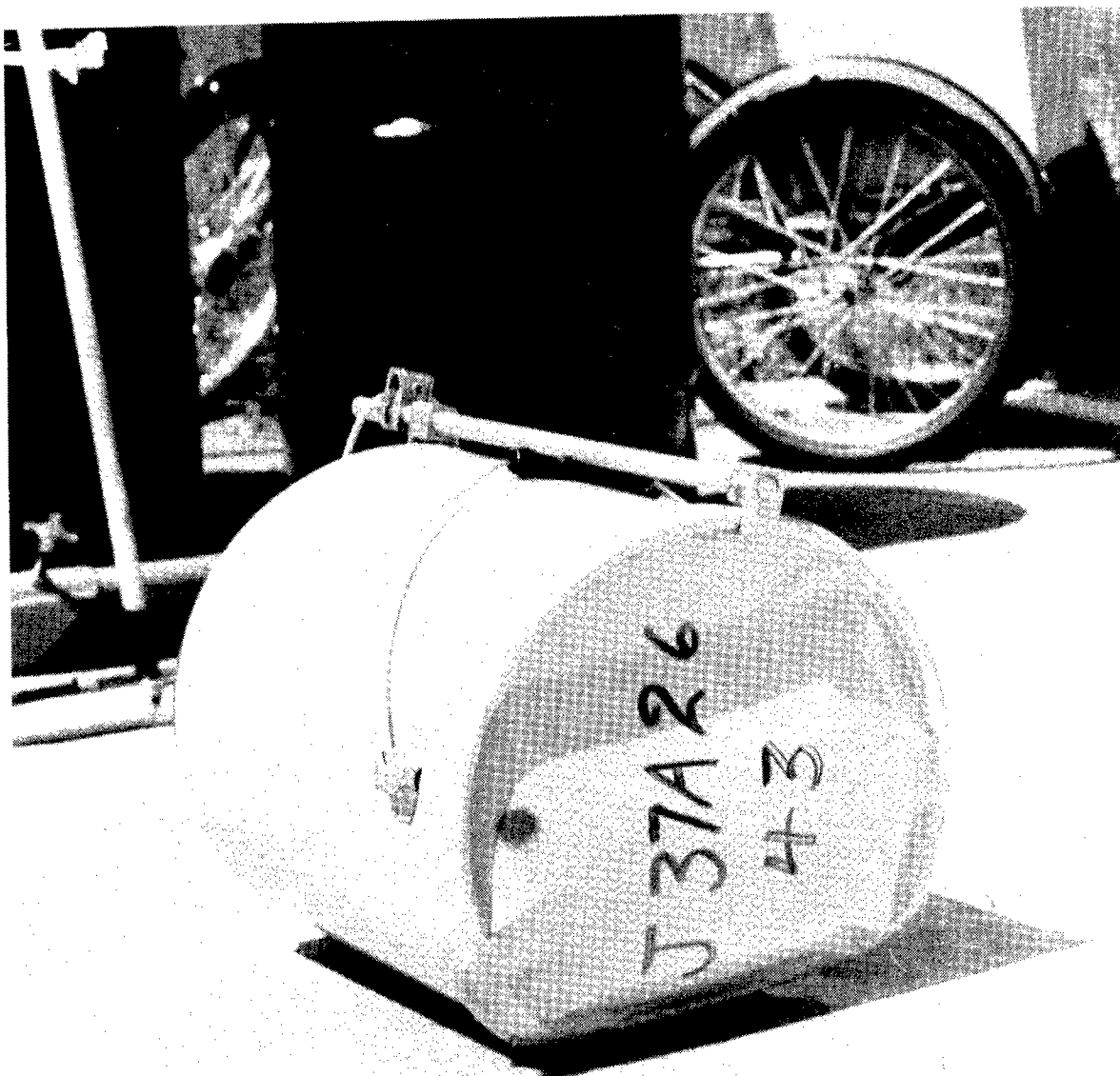


FIGURE 24

DIAGONAL DROP TEST



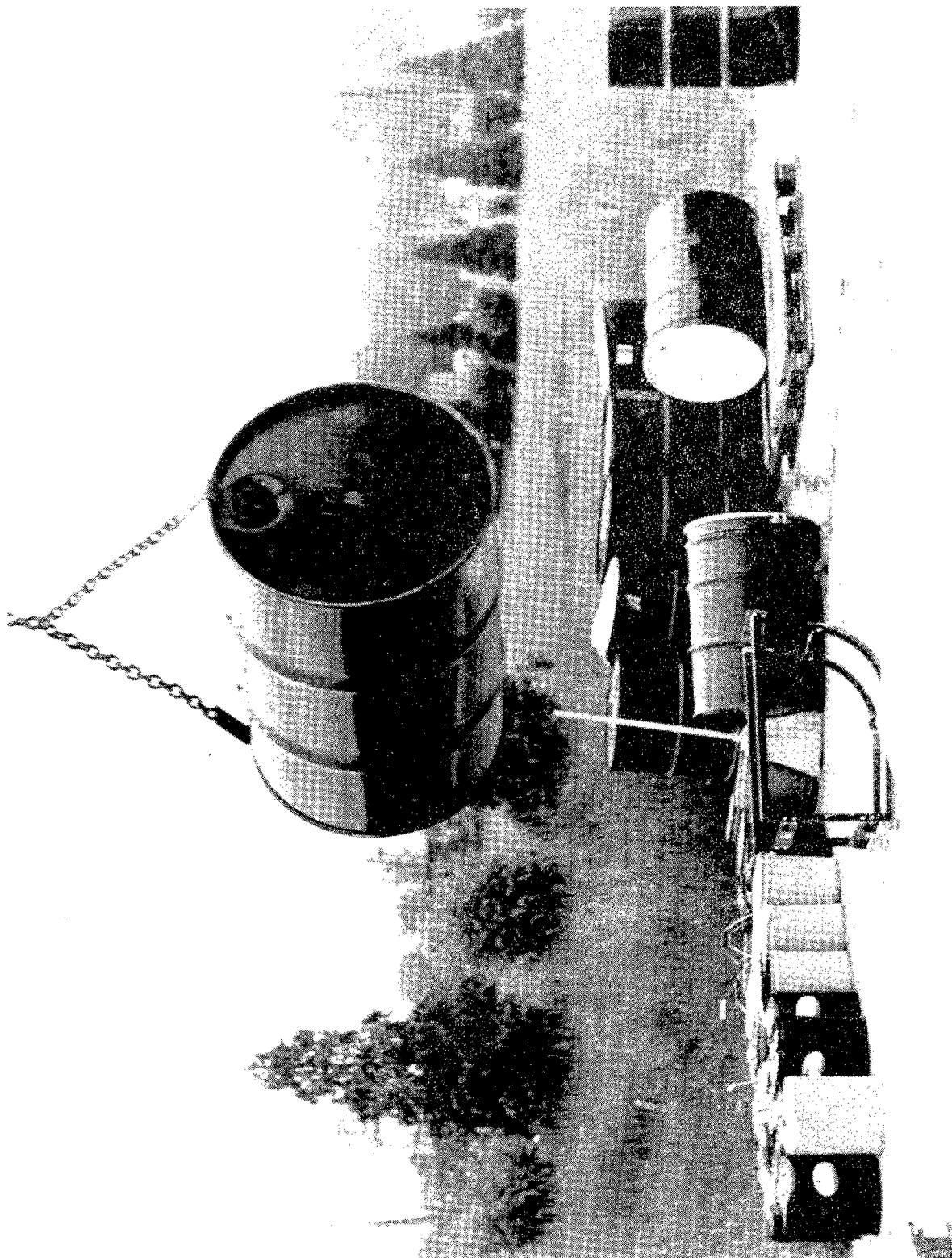
DIAGONAL DROP TEST

FIGURE 25



DIAGONAL DROP TEST

FIGURE 26



POSITION FOR HORIZONTAL DROP

FIGURE 27



FIGURE 28

HORIZONTAL DROP TEST



HORIZONTAL DROP TEST

FIGURE 29

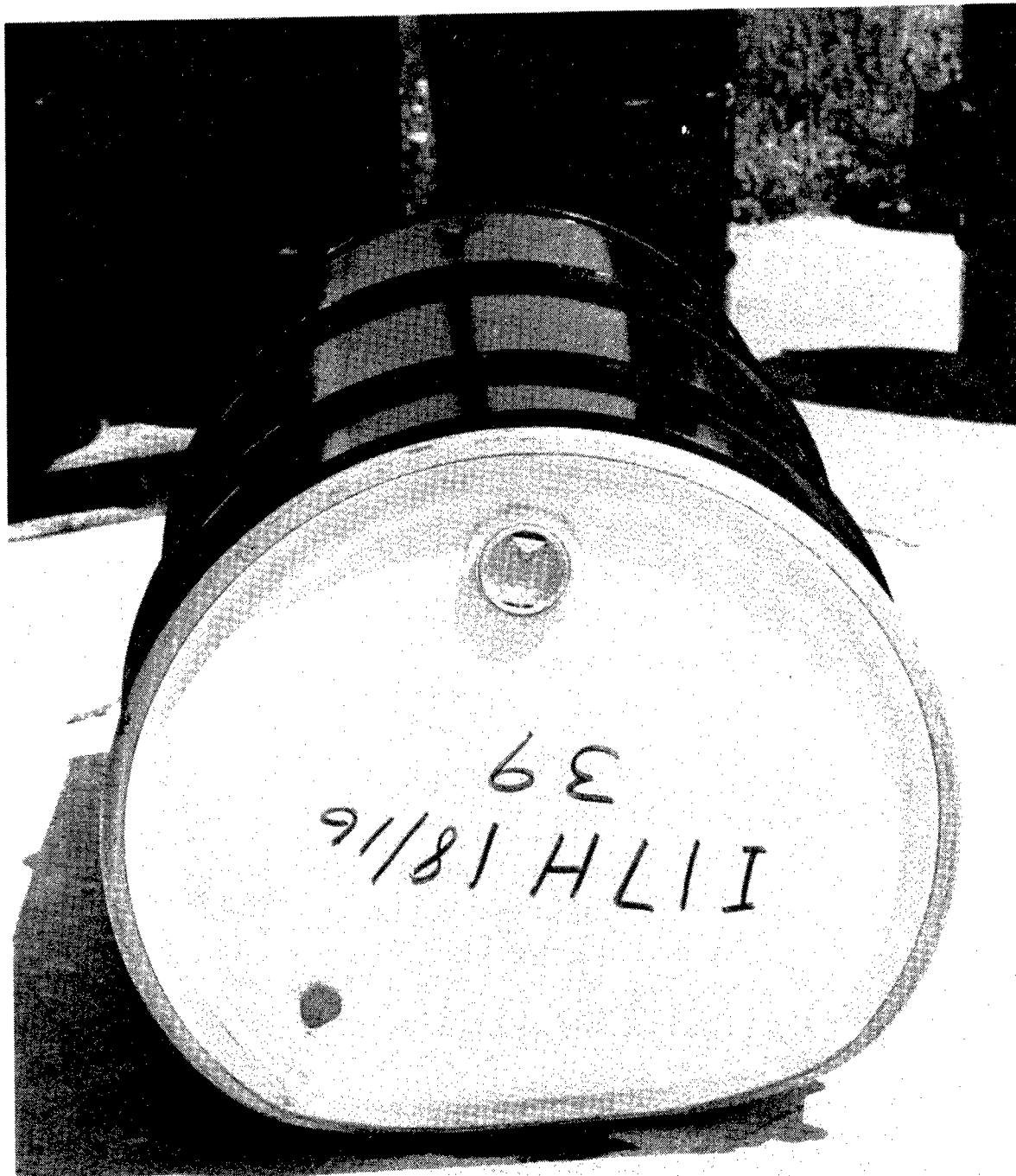


FIGURE 30

HORIZONTAL DROP TEST



FIGURE 31

HORIZONTAL DROP TEST



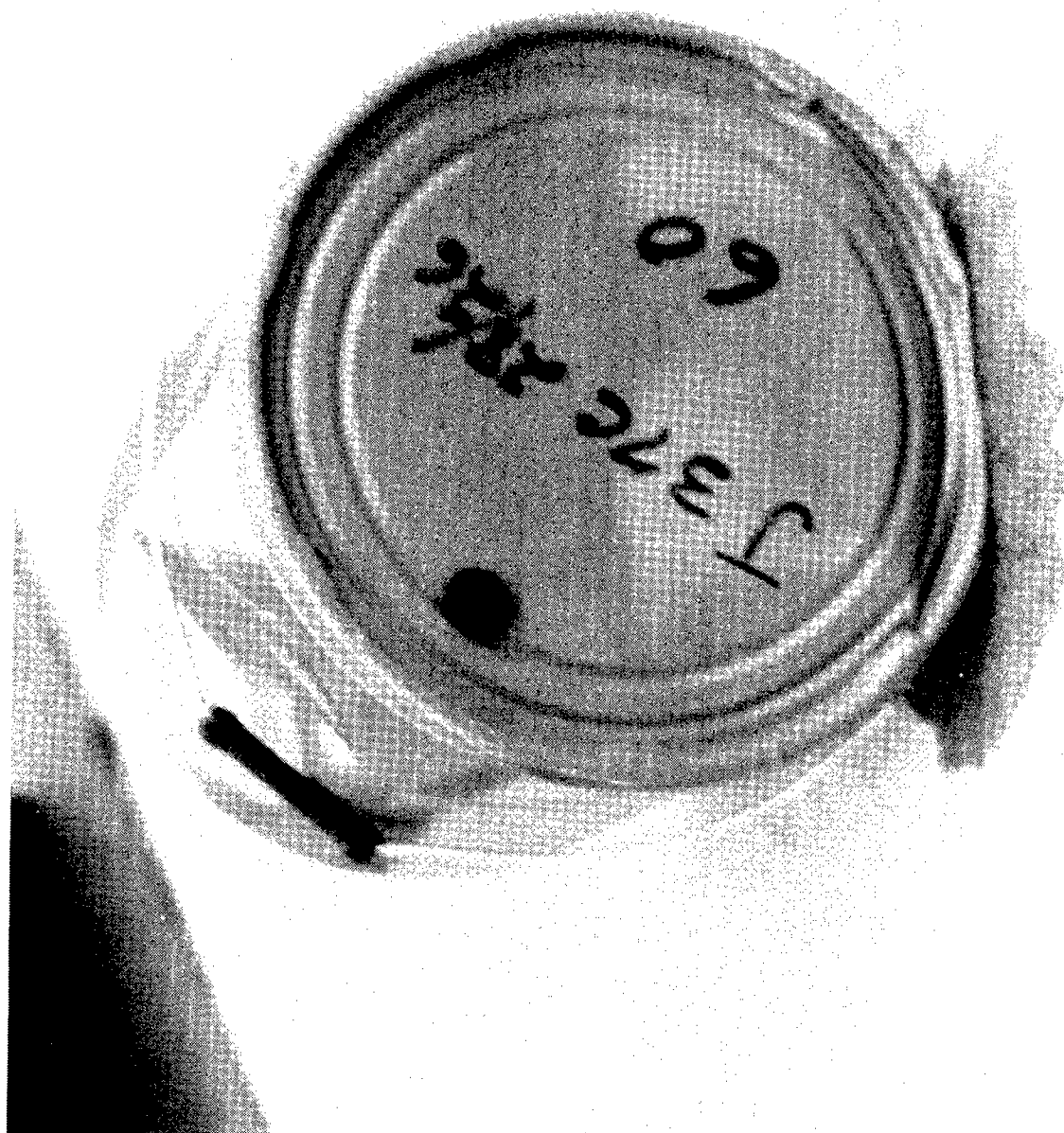
HORIZONTAL DROP TEST

FIGURE 32



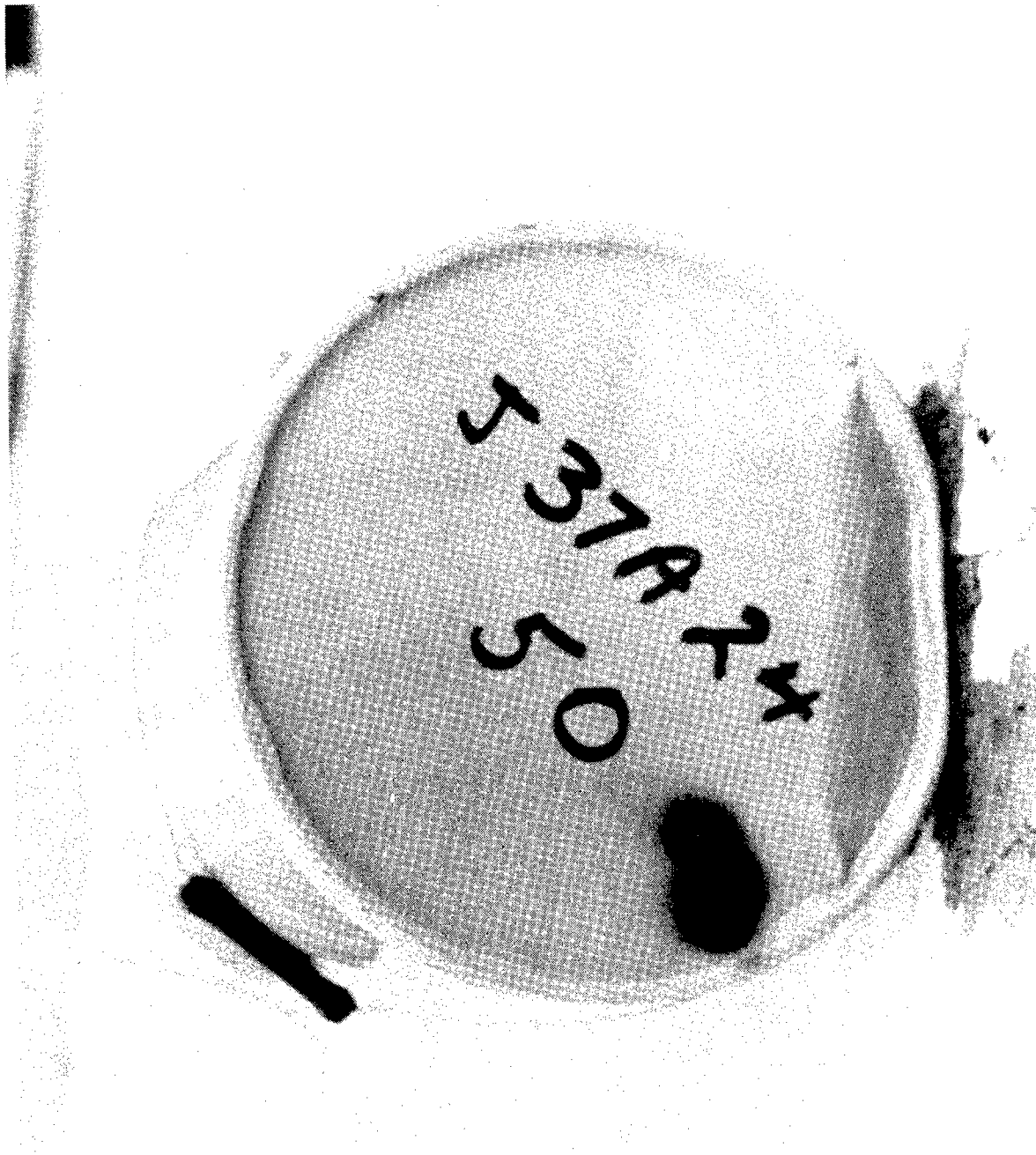
HORIZONTAL DROP TEST

FIGURE 33



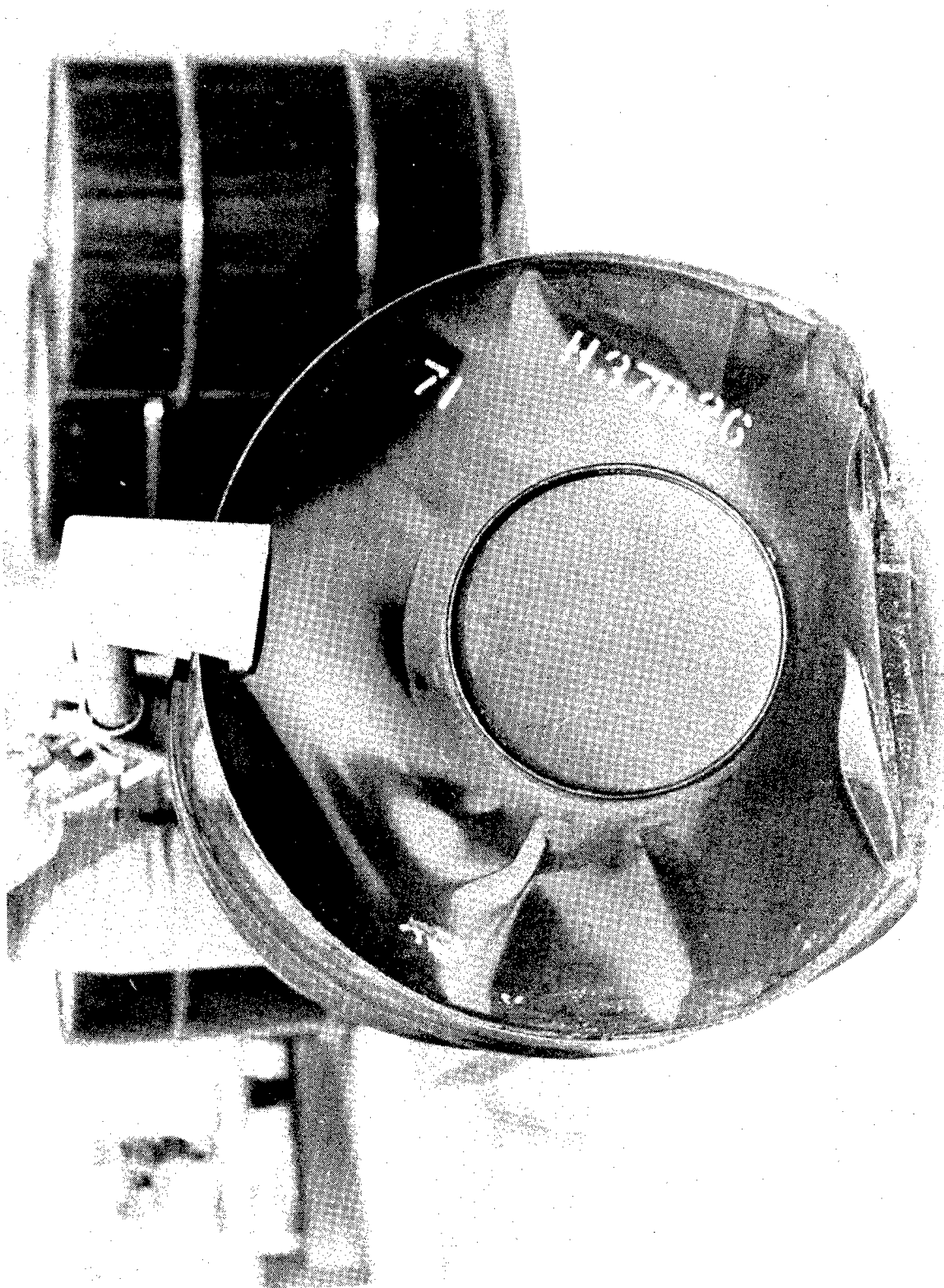
HORIZONTAL DROP TEST

FIGURE 34



HORIZONTAL DROP TEST

FIGURE 35



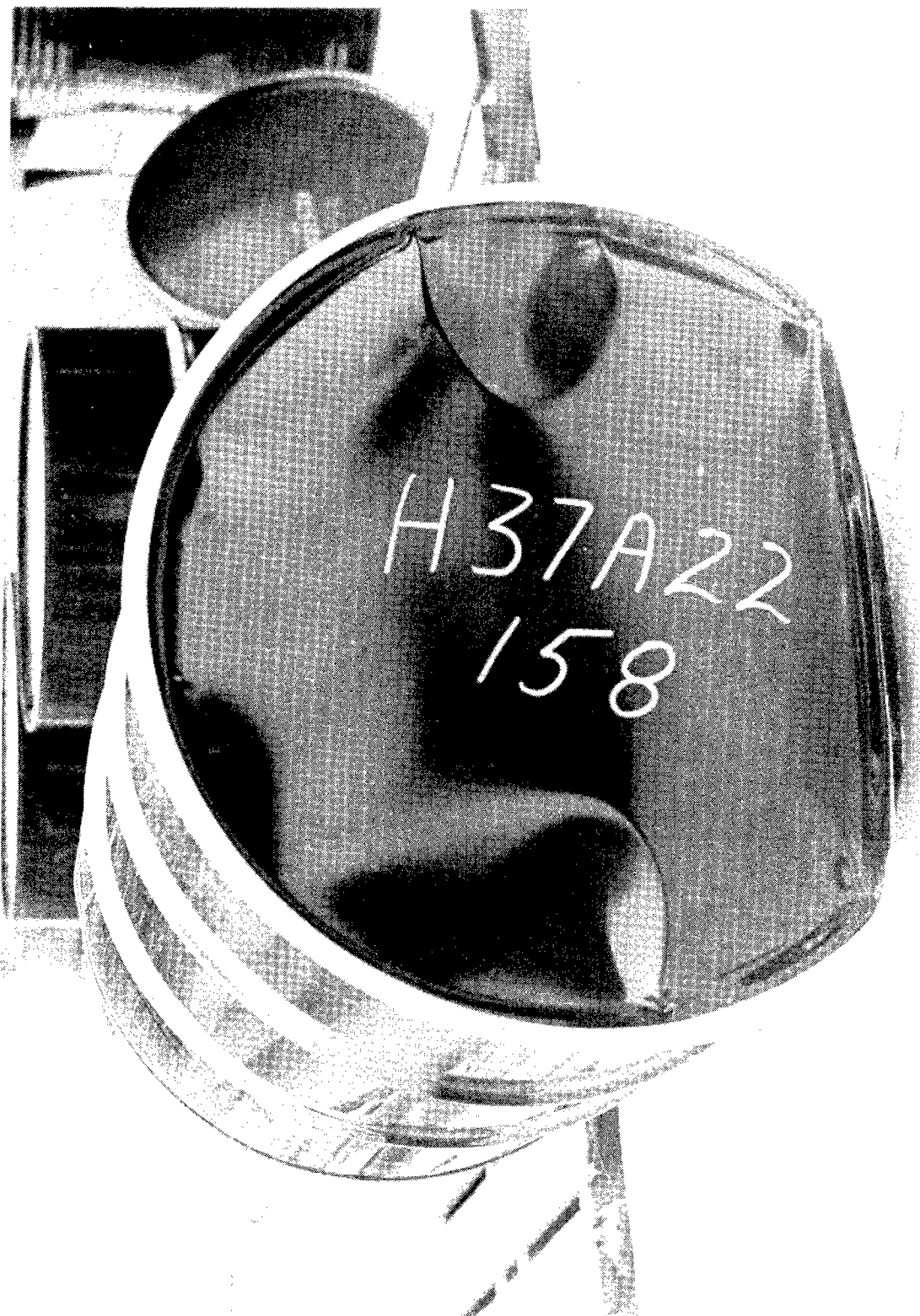
DIAGONAL DROP TEST, POWDER

FIGURE 36



DIAGONAL DROP TEST, POWDER

FIGURE 37



DIAGONAL DROP TEST, POWDER

FIGURE 38

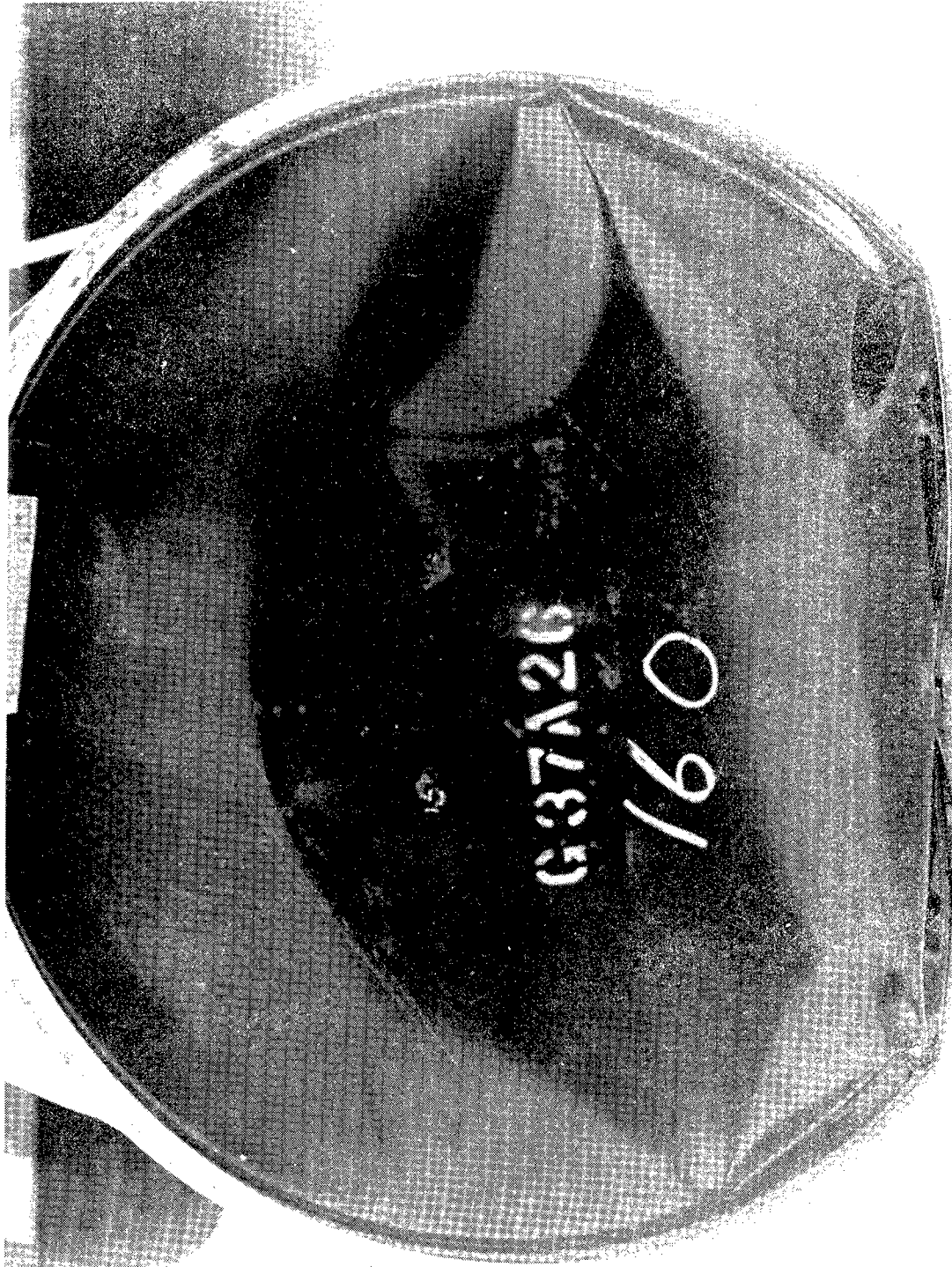
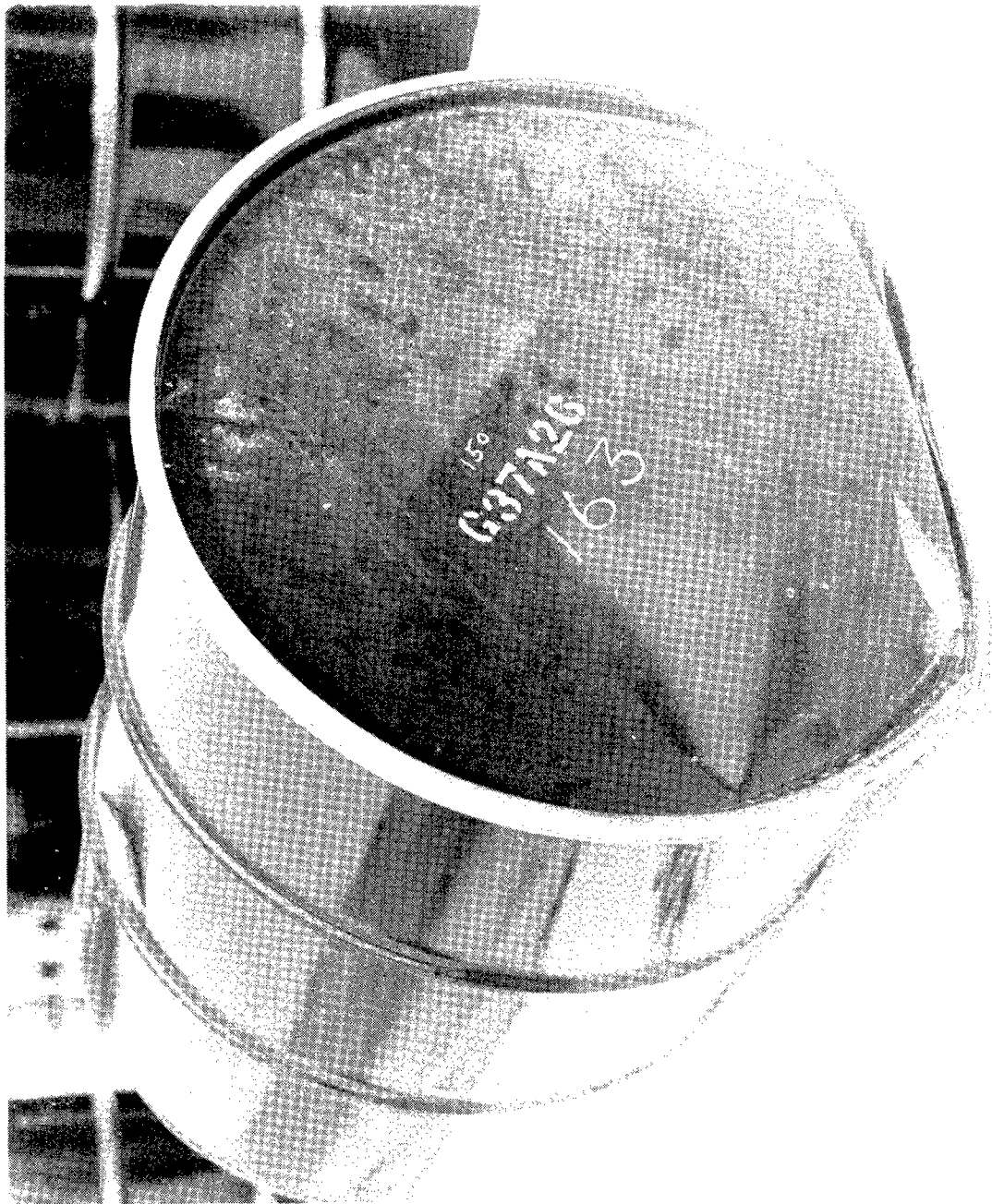
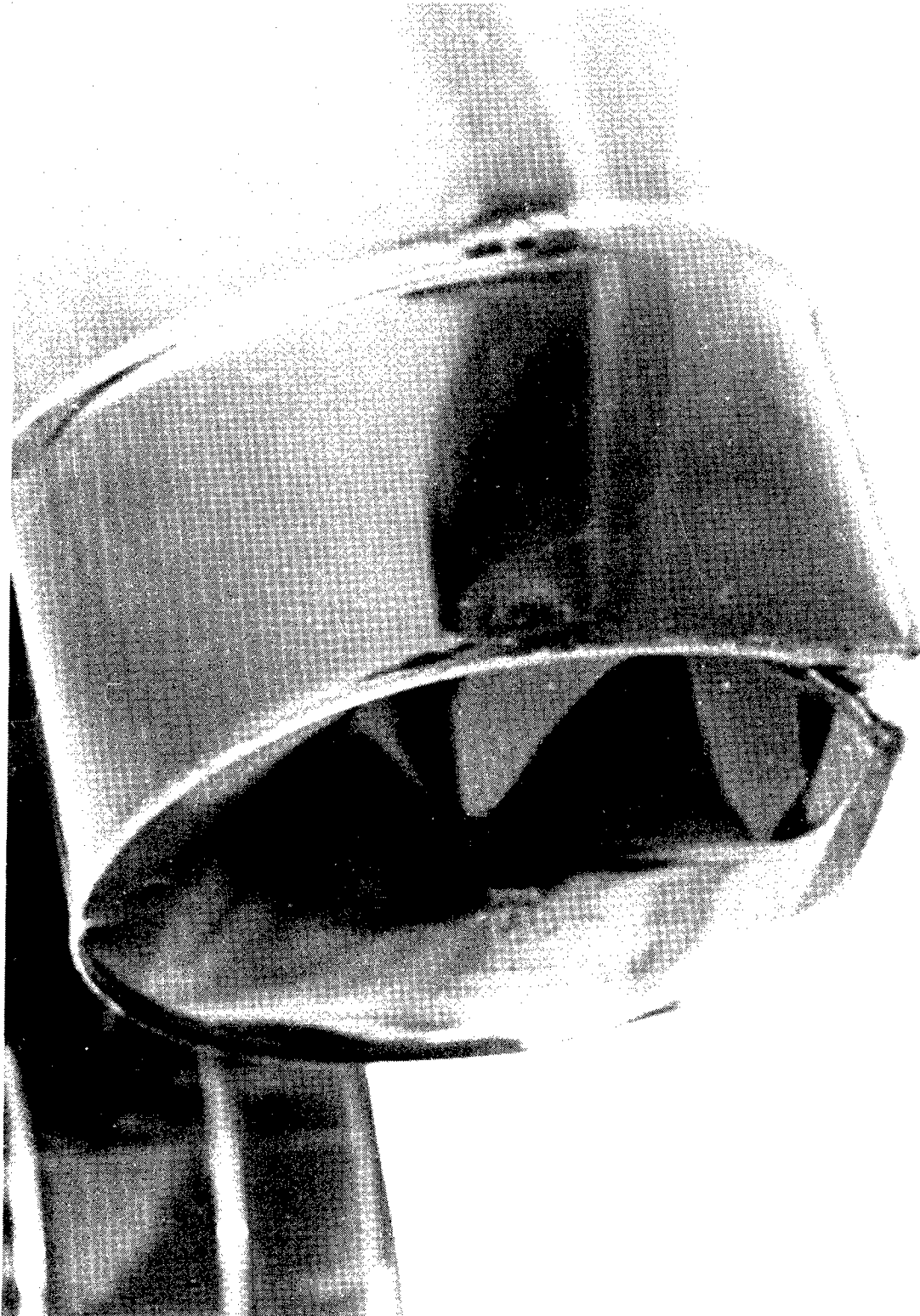


FIGURE 39 DIAGONAL DROP TEST, POWDER



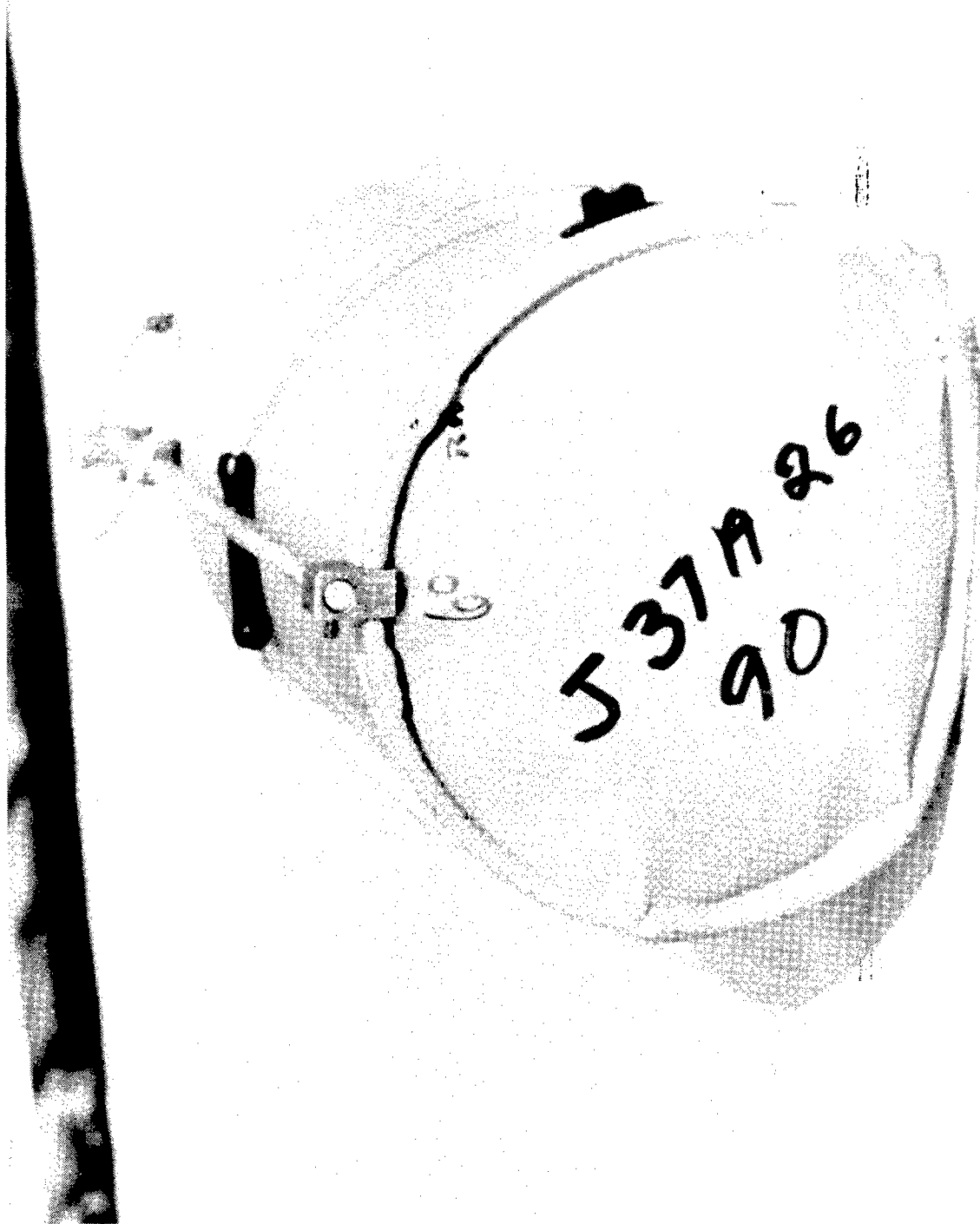
HORIZONTAL DROP TEST, POWDER

FIGURE 40



HORIZONTAL DROP TEST, POWDER

FIGURE 41



DIAGONAL DROP TEST, POWDER

FIGURE 42

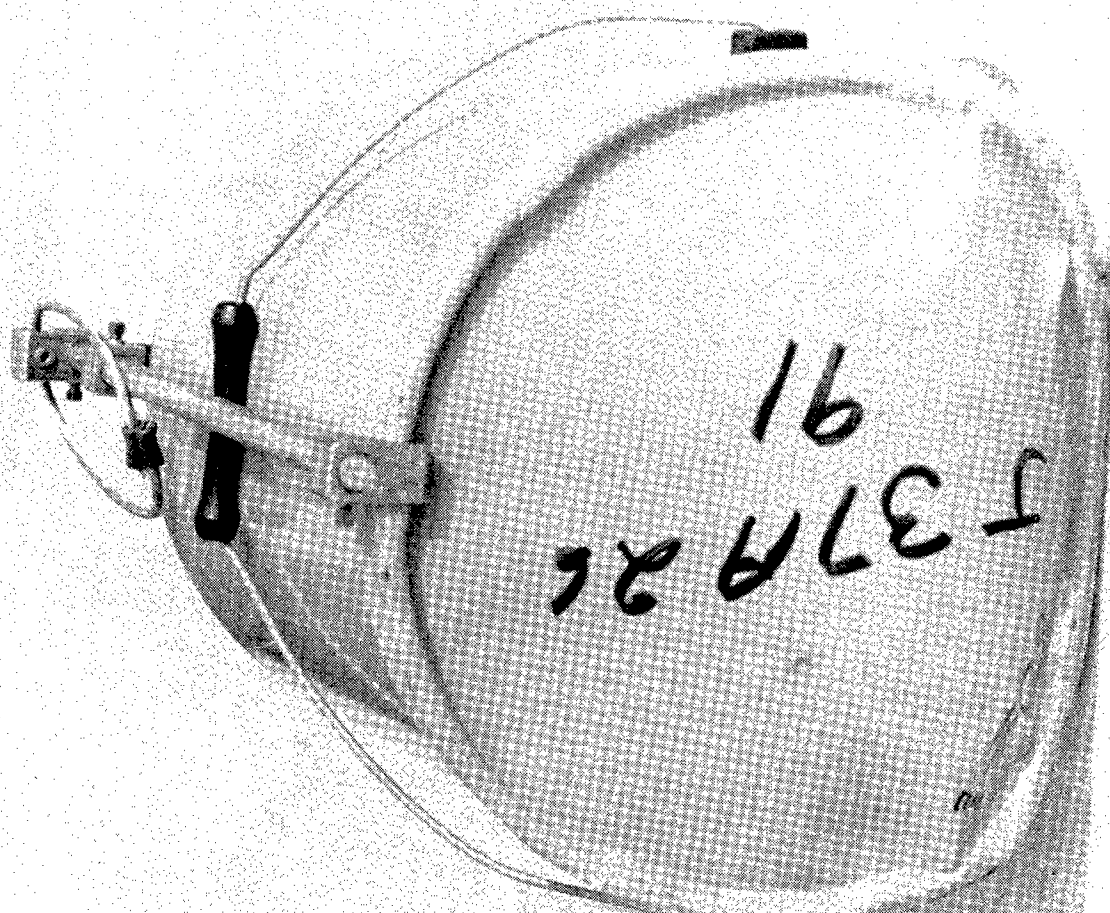


FIGURE 43 DIAGONAL DROP TEST, POWDER



FIGURE 44
DIAGONAL DROP TEST, POWDER



FIGURE 45 DIAGONAL DROP TEST, POWDER

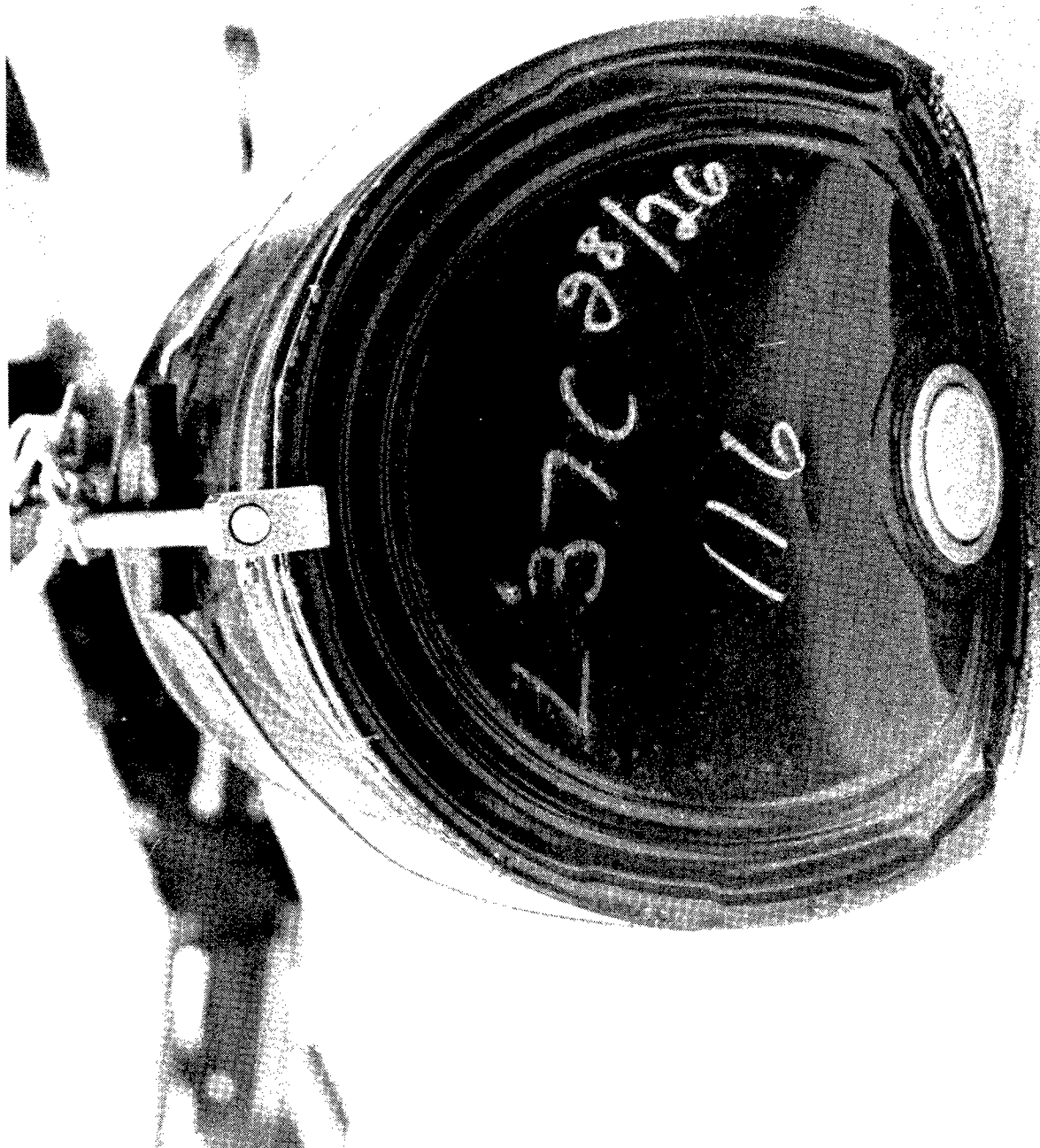


FIGURE 46 DIAGONAL DROP TEST, POWDER

A P P E N D I X

VISITORS THAT WITNESSED THE TESTS

APPENDIX
VISITORS THAT WITNESSED THE TESTS

<u>Date</u>	<u>Name</u>	<u>Activity</u>
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5/19/72	J. Higgins A. Calipristi	U.S. Steel DOT
5/22/72	A. Nides P. Urasky E. Berryman J. Higgins	SSCI * SSCI * U.S. Steel
5/23/72	W. J. Burns A. Nides A. Calipristi P. Urasky R. Deeds	DOT SSCI * DOT DOT
5/24/72	J. Higgins E. Stark A. Murphy J. Gotts Mr. Raw Mr. Fridinger	U.S. Steel Rheem Manufacturing Manion Steel NOL NOL NOL
5/26/72	E. Stark E. R. Byrne J. Higgins L. Trilla L. Baruch Jr. E. Berryman	Rheem Manufacturing Eastern Steel Barrel U.S. Steel Trilla Steel Drum Trilla Steel Drum SSCI *
7/11/72	P. Beal W. Berry	Greif Brothers

*Steel Shipping Container Institute

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13. ABSTRACT <p>An investigation was conducted to evaluate various types of new metal drums and pails being used for the packaging and shipping of hazardous materials, to determine if these containers will spill their contents when subjected to high internal pressure and to specified rough handling tests. Various quantities of 17H and 17C open head drums as well as samples of 37A and 37C drums and pails spilled liquid contents after rough handling. In addition, some 37A, 37B drums and 37A and 37C pails spilled their dry (powder) contents after rough handling.</p>			